APPENDIX B

HABITAT ANALYSES AND DATA

CONTENTS

FIGURES

TABLES

YAKIMA PROJECT BASE MAPS *(in color, following page B-50)*

B-1. SUMMARY

Selected tributaries upstream from five U.S. Bureau of Reclamation storage reservoirs in the "Upper Yakima Basin"[1/] were assessed to determine the amount of spawning and rearing habitat that would be available and accessible for anadromous salmonids and the potential for improving connectivity among populations of native fish and native aquatic species if fish passage were provided at the five dams.

The length in miles of tributary stream habitat up to natural or manmade barriers that would be immediately available and accessible to anadromous salmonids was estimated. The fisheries subteam also estimated where possible the additional length of tributary stream habitat that might be available if manmade barriers to fish passage such as improperly placed culverts or other obstructions were replaced and/or improved to allow fish passage. A qualitative evaluation of the spawning and rearing habitat in the tributary streams was attempted based on numerous environmental variables such as stream gradient, reported assessments of the quality of spawning conditions, available information on water temperature, habitat conditions including large woody debris, and pool frequency and quality.

Information was collected from agency reports and peer-reviewed papers, as well as personal observations of the subteam participants. Quality and availability of information relative to spawning and rearing habitat for anadromous salmonids was not uniform for all tributary streams, so a quantitative comparison among tributary streams was not possible. Much of the information was entered into a tributary habitat matrix, include in this Phase I Assessment report as Appendix C.

Estimated overall reservoir tributary stream length in miles of suitable spawning and rearing habitat that would be accessible to anadromous salmonids if passage were provided at the several dams is shown in Table B-1-1, along with tributary stream length if manmade fish passage barriers such as culverts are replaced and/or improved.

TABLE B-1-1. EXISTING AND POTENTIAL HABITAT FOR ANADROMOUS FISH

Reservoir	Stream Habitat (in miles)	
	Currently accessible	**Potentially available above manmade barriers**
Keechelus Lake	13.8	16.8
Kachess Lake	2.35	TBD
Cle Elum Lake	16.8	TBD
Bumping Lake	6	TBD
Rimrock Lake	36.8	TBD
TBD = to be determined		

1 "Yakima Basin" designates the entire Yakima River watershed, from the Columbia River to the headwaters of the mainstem and all its tributaries;
"Lower Yakima Basin" is the area downstream from Parker gage (RM 107.1) to the Columbia River;
"Upper Yakima Basin" is the area from Parker gage to the headwaters of the mainstem and all tributaries;

Sections of some tributary streams such as Gold Creek above Keechelus Dam are dewatered seasonally for varying periods of time, usually in the later summer-early fall, which would impede potential migration of some anadromous salmonids and migration of local populations of bull trout to and from their spawning and overwintering habitats.

No attempt was made to calculate increases or changes in anadromous salmonid production as a result of habitat expansion upstream from reservoirs; quality and quantity of available and accessible reservoir tributary habitat was used as a surrogate for production in this first phase report.

In addition, the response of the population to newly accessible tributary habitat would not likely be apparent for at least several generations, so long-term observations and monitoring would be required to assess the biological benefits of fish passage. Environmental conditions in the Columbia River migration corridor, the estuary, and the ocean will also affect the population response of anadromous salmonids in the Yakima Basin.

B-2. INTRODUCTION AND BACKGROUND

2.1 PURPOSE AND SCOPE

This report assesses the quality and quantity of selected tributary habitat upstream from five U.S. Bureau of Reclamation (Reclamation) Yakima Project storage reservoirs relative to providing passage for anadromous salmonids and native resident fish at the dams. There are five major storage reservoirs including Keechelus, Kachess, and Cle Elum lakes in the upper Yakima Basin, and Bumping and Rimrock lakes in the Naches River basin. Clear Lake is a small reservoir upstream from Rimrock Lake that presently has no active storage. Its fish ladder functions poorly and is ineffective in providing fish passage. For the purpose of this study, we assumed that this ladder would be repaired in the foreseeable future.

This assessment includes investigations as to engineering, constructability, biological, and operational considerations of upstream and downstream fish passage at each facility, the potential benefits for restoring anadromous salmonid runs to suitable habitat above each reservoir, and restoring connectivity for native fish, including isolated populations of bull trout. There is a disparity of information across all tributaries and reservoirs so an uniform set of criteria for comparison could not be developed.

2.2 IMPACTS TO FISH FROM BASIN DEVELOPMENT AND PROJECT OPERATIONS

The Yakima River watershed supports anadromous stocks of spring chinook salmon, fall chinook salmon, coho salmon, and summer steelhead. Sockeye salmon were present historically, but have been extirpated. The watershed also supports several other resident salmonids including: bull trout, rainbow trout, cutthroat trout, and mountain whitefish. Additionally, several non-native salmonids have been introduced to the Yakima Basin including brook trout and brown trout. Prior to 1855, an estimated 300,000 to 800,000 anadromous fish returned to the Yakima Basin each year (WDFW 1993, Neilsen et al. 1991). Davidson (1953) estimated 500,000 chinook salmon (all races); Mullan (1983) estimated about 100,000 coho salmon; Smoker (1956) estimated 100,000 steelhead; the historical total run size of Yakima River sockeye salmon has been estimated to be either 100,000 (Davidson 1953) or 200,000 (CBFWA 1990).

There were dams on the river prior to the construction of the five Yakima Project (the Project) storage dams. Crib dams without fish passage facilities were constructed at Keechelus Lake and Kachess Lake (in 1904) and at Cle Elum Lake (in 1905); these eliminated sockeye salmon populations in these lakes (Bryant and Parkhurst 1950, Davidson 1953, Fulton 1970, Mullan 1986). An impassable storage dam was constructed at Bumping Lake in 1910; this likewise eliminated a sockeye salmon population in that lake, with an estimated annual run of 1,000 fish (Davidson 1953, Fulton 1970). These four crib dams were obliterated or removed when the five Project storage dams were constructed; four to enlarge existing natural glacial lakes and one on-stream storage facility (Tieton Dam). These crib dams initially blocked fish passage to tributaries upstream from the dams, resulting in the eventual demise of the sockeye salmon runs by the early 20th century, the elimination of access to previously productive spawning and rearing habitat for spring chinook salmon and coho salmon and steelhead, and genetic isolation of formerly interconnected resident fish populations, especially bull trout.

Irrigation projects were developed prior to the time when the Reclamation storage projects were authorized and constructed. Numerous irrigation diversion dams on the mainstem Yakima River and its tributaries precluded anadromous fish from accessing portions of the watershed; unscreened diversions entrained salmon and steelhead smolts on their outmigration to the ocean, redirecting them instead to their death in agricultural fields. Dam construction on the mainstem Columbia River (which resulted in additional loss of downstream-migrating smolts) coupled with substantial commercial, tribal and recreational harvest of returning adults further decimated the numbers of anadromous salmonids returning to the Yakima Basin.

2.3 FISH SPECIES AFFECTED BY YAKIMA STORAGE RESERVOIRS

Four of the five Project storage reservoirs were originally natural lakes and supported Native American fisheries for sockeye salmon and other anadromous and resident fish. While detailed information is not available for pre-Project fish population abundance in these lakes, it is reasonable to assume that some of the native salmonid species currently found in the river reaches downstream from the dams would have been able to migrate upstream prior to the dams' construction, and would have been present there historically, where suitable habitat conditions existed in the watersheds above the dams. Sockeye salmon and coho salmon were present; however, endemic Yakima Basin stocks of sockeye salmon and coho salmon are extinct. Coho salmon currently returning to the Yakima River are descendants from a mix of hatchery stocks. The fifth reservoir (Rimrock Lake) was not originally a natural lake, and therefore the watershed upstream would not have supported sockeye salmon and burbot that require a lake environment for some portion of their life history, but the river and tributaries could have been used by salmon and steelhead.

Anadromous salmonids are expected eventually to recolonize the watersheds upstream from the storage dams if fish passage were provided. Local populations of native fish such as bull trout would have a pathway through which to interact with other local populations.

2.4 NEED FOR RESTORATION OF FISH PASSAGE

There are several biological reasons for providing fish passage at Yakima River storage projects, including increasing or enhancing populations of upper basin steelhead, and coho and spring chinook salmon by restoring access to historically occupied habitat; restoring life history and genetic diversity of salmonids and other native fish; reintroducing sockeye salmon to the watershed where they occurred historically, and reconnecting isolated populations of bull trout. Over time, if fish passage were provided, anadromous salmonids are expected to recolonize and expand into the watersheds upstream from the storage dams as populations in the rivers downstream from the storage dams increase in abundance. Some effort might be needed to expedite the restoration. Bull trout populations would experience restored historic connectivity and increased gene flow among the presently isolated populations.

There are several administrative requirements and justifications for restoring fish passage, such as the conditions of a Washington Department of Fish and Wildlife-Bureau of Reclamation mitigation agreement; Washington state law regarding fish passage (RCW 77.55.060); conditions of a Washington state "Hydraulic Project Approval" (HPA # 00-E1998-01); and Reclamation-State of Washington commitments associated with the Keechelus Dam Safety of Dams project. Furthermore, the Yakama Nation has a strong interest in restoring native salmon runs. In addition, NOAA Fisheries (National Marine Fisheries Service, NMFS) and Reclamation negotiated a Reclamation-driven study to examine fish passage at the five Project storage reservoirs, and the *Biological Opinion on the Federal Columbia River Power System* (NMFS 2000) includes a conservation recommendation that reiterates this commitment on the part of Reclamation.

2.5 POTENTIAL OUTCOMES OF ACTIONS

There are numerous potential outcomes of an assessment of fish passage options and reservoir tributary habitat. These include a plan or guidance for systematic construction of fish passage facilities at Yakima River storage dams; modification of reservoir and Project operations to facilitate upstream and downstream fish passage; implementation of fish passage or habitat improvement projects in tributary streams that complement fish passage efforts at dams; and modification of fisheries management practices (harvest, supplementation, etc.) to complement fish passage efforts and facilitate restoration of anadromous salmonid populations upstream from the dams.

The Phase I assessment of tributary habitat upstream from five storage reservoirs will not attempt to estimate potential fish production in habitat available after fish passage is provided or restored, but will describe the quality and quantity of tributary habitat where information is available (tributary stream miles accessible now, tributary stream miles accessible after the removal of manmade barriers such as culverts, quality of spawning and rearing habitat, etc.) as a surrogate for estimating fish production. Much of the information on which these assessments are based is found in the matrices in Appendix C. It is premature in this Phase 1 Assessment report to discuss long-term sustainability of anadromous salmonid populations as a result of providing passage at dams and access to previously occupied or new habitat in reservoir tributaries and their contribution to the overall status of populations due to the numerous unknown factors and environmental variables that affect population sustainability.

Bull trout and other native fish populations will be reconnected, thus providing for genetic exchange and expanded foraging and overwintering habitat.

B-3. SPECIES MIGRATION TIMING

In order to evaluate fish passage options for both upstream and downstream migration of anadromous and resident fish, it was necessary to estimate the timing of both adult and juvenile migration for the target fish species considered most likely to benefit from providing passage at reservoirs — spring chinook, coho, and sockeye salmon; steelhead; and bull trout. This information was consolidated into several tables showing estimated passage timing for adults and juveniles of all species individually, as well as a composite table combining all species for upstream and downstream passage (tables B-3-1 through B-3-4). Because fish passage at the dams is not currently provided and because certain runs such as sockeye salmon are no longer present in the Yakima Basin, these tables were developed using the professional judgment of the interagency team of biologists participating in the evaluation, as well as being informed by available data such as the timing of salmon runs as they return to the lower Yakima River.

In general, juvenile fish primarily outmigrate during the spring (March-June) and fall (late September through November). Juvenile fish would be least active during the winter months (December-February). Spring outmigrants are generally juvenile fish that are seeking habitat in larger streams or rivers or fish that are actively migrating to the ocean. A notable departure from this migration pattern is sockeye salmon, which may migrate upstream to a lake as emergent fry (Burgner 1991) in search of lacustrine habitat. In fall, juvenile fish may also migrate downstream, a behavior commonly described as a search for over-wintering habitat.

Adult salmon and trout typically migrate upstream seeking spawning habitat. Anadromous fish such as chinook salmon or steelhead travel thousands of miles throughout their lives and may migrate to a location near their spawning habitat months before they are ready to spawn. Resident fish species such as bull trout or rainbow trout may migrate upstream or downstream throughout a river system and may undertake a protracted spawning migration. Some species such as rainbow trout and steelhead spawn in the spring; other species such as salmon or bull trout spawn in the fall, thus the time period for upstream migration of all adult salmonids could extend from approximately March through November. Some species such as bull trout and steelhead are iteroparous (can spawn more than once) and thus adult fish could also migrate downstream after spawning. Time periods for downstream migration of iteroparous species will vary but would probably be early summer or fall after the fish have spawned.

Although the timing of peak adult upstream migration would differ between the two arms (the Naches River and the upper mainstem Yakima River), peak timing of downstream juvenile migration should be similar in both arms (table B-3-4). Because of the number of salmonid species that would be involved eventually in restoration and the different expressions of their life histories, it is reasonable to assume that nearly year-round fish passage would be required, considering all five Project storage projects.

TABLE B-3-1. UPSTREAM MIGRATION OR PASSAGE TIMING FOR ADULTS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Spring chinook salmon												
Coho salmon												
Sockeye salmon												
Bull trout												
Steelhead (Naches)												
Steelhead (Yakima)												
		= General Migration Period						= Peak Migration Period				

TABLE B-3-3A. DOWNSTREAM MIGRATION OR PASSAGE TIMING FOR JUVENILES

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Spring chinook salmon												
Coho salmon												
Sockeye salmon												
Bull trout												
Steelhead (Yakima)												
Steelhead (Naches)												

TABLE B-3-3B. DOWNSTREAM MIGRATION OR PASSAGE TIMING FOR KELTS AND ADULTS

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Steelhead kelts (Yakima)												
Steelhead kelts (Naches)												
Bull trout adults												
		= General Migration Period						= Peak Migration Period				

TABLE B-3-3. COMPOSITE UPSTREAM MIGRATION OR PASSAGE TIMING

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Yakima River												
Naches River												
		= General Migration Period						= Peak Migration Period				

Note: Table represents adult passage only for spring chinook, coho, sockeye salmon; steelhead; and bull trout. Juvenile (and/or subadult) upstream passage timing for sockeye salmon and bull trout is still being researched.

Table B-3-4. Composite Downstream Migration or Passage Timing

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Basin-Wide juveniles												
Yakima River adults												
Naches River adults												
		= General Migration Period						= Peak Migration Period				
* Juveniles for species identified above. Adults are steelhead kelts and bull trout												

B-4. TRIBUTARY HABITAT CONDITIONS

In this section, we discuss quality and quantity of potentially accessible tributary habitat that would likely be available to anadromous salmonids if upstream and downstream passage were provided at the dams. There are an estimated 1,380 miles of anadromous salmonid habitat (total of known, presumed, and historic use) in the Yakima River watershed. Utilization of this habitat has been affected to varying degrees, depending on the species. Much of the difference between current and historic use is due to restricted fish access, mostly associated with irrigation diversions and irrigation water storage throughout the watershed. The occurrence and severity of habitat limiting factors varies among streams and reaches within individual subwatersheds. The extent and quality of current salmonid utilization is impaired to varying degrees throughout the watershed by loss of floodplain function (including loss of side-channel habitat and reduced bank stability), increased presence of fines in the substrate that impairs spawning and rearing success and benthic invertebrate productivity, impaired riparian function, water quality impacts from agricultural runoff, and perhaps altered hydrology throughout much of the watershed due to land use and irrigation water delivery.

We also discuss the potential benefits to anadromous salmonid populations that would have access to historic spawning and rearing habitat. Migratory bull trout would be expected to gain increased population connectivity with fish passage at the dams. To assess quality and quantity of tributary habitat, we developed a matrix of habitat conditions and parameters for selected reservoir tributaries (presented in Appendix C) and from those matrices developed the narrative descriptions and semi-quantitative analyses provided below. As a general template for discussion, we follow to some extent the six abiotic and four biotic parameters described in the "Functional Analysis of Factors Limiting Natural Production" in the *Yakima Subbasin Summary* (NPPC 2001).

The six abiotic parameters include

(1) **water quality** — temperature, suspended sediment, turbidity, chemical pollution/pesticides, nutrient concentrations, dissolved oxygen, and biological oxygen demand;

(2) **habitat accessibility** — presence of physical barriers to anadromous salmonids;

(3) **habitat structure** — pool frequency and quality, fine sediment delivery and deposition, size distribution of substrate, the quantity and distribution of large woody debris, off-channel habitat, and refugia;

(4) **channel conditions and dynamics** — width-to-depth ratio, streambank stability, channel stability, channel confinement and simplification, and floodplain connectivity;

(5) **instream flow/hydrology** — similarity of peak and base flows to normative values, similarity of drainage network to the historical drainage network, and mortalities caused by irrigation or hydropower diversions;

(6) **watershed condition** — road density, condition and location, disturbance history, and the quantity and distribution of riparian reserves.

The four major biotic elements include:

(1) **predation**, both inter- and intraspecific;

(2) **competition**, both inter- and intraspecific;

(3) **pathogens/parasites**;

(4) **mutualism** — species that benefit each other.

We will address the elements listed above for the reservoir tributaries where the data and information exist. Information was compiled from several sources, including but not limited to U.S. Forest Service (USFS) stream surveys, the "Habitat Limiting Factors Analysis" (Haring 2001), and the *Draft Yakima Subbasin Summary* (NPPC 2001). The HLFA provides a wealth of information and analysis and was used extensively in developing this Phase I report. The following general descriptions of salmonid habitat are principally derived from the HLFA (Haring 2001).

4.1 KEECHELUS LAKE

Keechelus Dam is located in the Wenatchee National Forest on the Yakima River in Kittitas County, approximately 10 miles northwest from Easton, Washington. It was constructed at RM 214.5 between 1913 and 1917 at the lower end of a natural lake in order to provide storage water for irrigation, recreation, flood control, and fish and wildlife purposes. Historically, Keechelus Lake had anadromous runs of sockeye, coho, and chinook salmon and steelhead. Resident fishes including bull and cutthroat trout would have had year-round access into and out of the lake.

4.1.1 Salmonid species potentially benefitting from fish passage facilities at Keechelus Dam

- Spring chinook salmon
- Coho salmon
- Sockeye salmon
- Steelhead
- Bull trout
- Mountain whitefish
- Rainbow trout
- Cutthroat trout
- Brook trout*
- Kokanee salmon

** (asterisk) indicates species not native to the Yakima River basin*

4.1.2 Assessment of Keechelus Lake tributary habitat conditions — Tributaries considered include Coal, Gold, Cold, Meadow, Mill, Townsend, and Roaring Creeks. Bull trout and anadromous salmonids may have used several tributary streams prior to the construction of Keechelus Dam. Gold Creek is the only tributary to Keechelus Lake that is documented to have historically supported anadromous salmonids and bull trout; it currently supports a remnant run of bull trout and historically may have supported spring chinook salmon, coho salmon, and summer steelhead. However, there is historical evidence of presence of bull trout in Rocky Run Creek (WDFW 1983) and it is likely populations existed historically in Meadow Creek and Coal Creek. At least three other tributaries to Keechelus Lake (Meadow, Cold, and Coal creeks) have potential to be restored to support anadromous salmonids and/or bull trout (surveys circa 1994 by Central Washington University students found only cutthroat trout in these streams; Brent Renfrow, WDFW, pers. comm.). Anadromous salmonids may have used historically the smaller tributaries such as Mill, Resort, and Roaring creeks, but data are lacking. Roaring, Resort, and Rocky Run creeks are considered to be too small or steep for anadromous fish. The best habitat in the smaller creeks would have been in the downstream area now inundated by the reservoir (reservoir drawdown photos indicate presence of likely suitable lower gradient habitat for anadromous salmonid juveniles, and even adults when adequate flow is present). Adult steelhead would most likely utilize these habitats when adequate flow is available. Currently, reservoir operations/inundation and man-made barriers (such as dam and some culverts) limit anadromous fish use of most of the smaller tributary streams.

The main floodplain modification that has occurred is the increased inundation area associated with the reservoir, which inundates the lower reach of each of the tributaries. Generally these lower tributary reaches were meandering, low-gradient channels with more complex habitat than that remaining upstream from reservoir full-pool elevation. Inundation alters the characteristic of the sediment-deposition fan at the mouth of each of the tributaries, and the repeated cycle of inundation/drawdown prevents the establishment of riparian vegetation and recruitment of large woody debris (LWD). These alterations affect the channel characteristics and impair fish passage into the tributaries during low flows at low pool levels. In addition, some portions of tributaries upstream from the inundation zone or full pool elevation have high gradients.

Table B-4-1 lists potentially accessible miles of tributary streams to Keechelus Lake, along with miles of stream potentially available upstream to natural barriers (falls, steep gradient, etc.) if manmade barriers (such as culverts) are removed. Reclamation plans to repair or replace the impassable culvert on Cold Creek.

TABLE B-4-1. KEECHELUS LAKE TRIBUTARY STREAMS WITH HABITAT CONSIDERED SUITABLE FOR MIGRATORY SALMONIDS

Tributary Stream	**Stream habitat** [miles (km)]		**Comments**
	Potentially accessible	**Potentially available above manmade barriers**	
Meadow Creek	3.9 (6.5)	3.9 (6.5)	Waterfall limits upstream migration (USFS 1995)
Gold Creek	7.0 (11.5)	7.0 (11.5)	Primary spawning stream for Keechelus; waterfall limits upstream migration (Craig 1997)
Cold Creek	0.0	1.9 (3.2)	Railroad culvert blocks access (USFS 1992)
Mill Creek	0.2 (0.32)	1 (1.6)	Railroad culvert blocks access; habitat surveys may be needed
Coal Creek	2.5 (4.2)	2.5 (4.2)	I-90 culverts and stream channelization limit access
Townsend Creek	0.2 (0.32)	0.5 (0.8)	I-90 culverts limit access
Total	***13.8 (22.2)***	***>16.8 (27.4)***	
Note: Other tributaries to Keechelus Lake were considered too small or steep to support migratory fish.			

Table B-4-2 shows conditions of tributary habitat in miles upstream from Keechelus Lake (USFS 1997).

TABLE B-4-2. HABITAT CONDITIONS UPSTREAM FROM KEECHELUS DAM (in miles)

Forest Planning Unit Habitat Type	**Good**	**Fair**	**Poor**
Tributaries to Keechelus Lake (excluding Gold Creek)			
Spawning habitat	9	11	33
Summer rearing habitat	19	22	11
Winter rearing habitat	19	7	26
Gold Creek			
Spawning habitat	6	2	12
Summer rearing habitat	8	4	9
Winter rearing habitat	8	1	11
Source: USFS 1997			

4.1.3 Summary — If fish passage were provided at Keechelus Dam, Gold Creek and Meadow Creek would be the most likely tributaries accessible to anadromous salmonids, and would amount to about 11 miles of suitable habitat accessible. Cold Creek and Coal Creek are each less than 3 miles long, with passage barriers relatively close to the mouth. However, if the fish barrier on Cold Creek were removed and replaced with an on-grade culvert, an additional 2 or so miles of stream habitat could be available and accessible to anadromous salmonids. Bull trout are documented in Gold Creek but not in the other tributaries. Historic use of these tributaries by anadromous salmonids is unknown. Habitat quality in the several tributaries varies, due to substrate composition, water temperatures, or riparian or stream channel conditions that do not meet USFS "Forest Plan" standards,[2] or passage barriers relatively close to the mouth.

Many of the current barriers in streams on the east side of the reservoir occur along the Interstate 90 corridor and are expected to be fixed during the I-90 expansion project by the Washington State Department of Transportation (WDOT). The "Aquatic Species Discipline Report" for the Interstate 90-Snoqualmie Pass East Project (WDOT 2001) provides detailed information on barriers, species present, temperatures and habitat conditions.

Based on a surface spill elevation of Keechelus Lake for Water Years 1994-2001, spill of Keechelus Lake down to elevation 2507 feet (the elevation of the existing spillway) would provide a limited period of volitional passage of juvenile fish. Increasing spill to elevation 2497 feet would provide additional volitional juvenile fish passage in most years, while going down to elevation 2480 feet would increase the opportunity for volitional juvenile passage in drier years like the last few years, but also cover periods when it is unlikely juvenile fish would be outmigrating. Figure 1 in Appendix D shows that during many years, even spill at elevation 2480 feet would not overlap entirely the fall juvenile migratory period.

4.2 KACHESS LAKE

Kachess Dam is located in the Wenatchee National Forest in Kittitas County, about 2 miles northwest from Easton, Washington. It was constructed between 1910 and 1912 at RM 1.0 on the Kachess River and was improved in 1936 (a reinforced concrete spillway was built on the right abutment). The intake tower was reconstructed in 1996-1997. The dam is a zoned, rolled, earth-fill structure with a height of 115 feet, a hydraulic height of 69.25 feet, a crest width of 20 feet, and a crest length of 1,400 feet. The lake has a surface area of 4,535 acres, a drainage area of about 63 square miles, an active storage capacity of 239,000 acre-feet, and dead-storage capacity of 671,272 acre-feet (USBR 1981). As such, it has the second-largest active storage capacity in the Yakima River watershed.

Nearly all the Kachess River watershed is inaccessible to anadromous salmonids, due to presence of Kachess Dam. Historically, the natural lake had anadromous runs of sockeye salmon, coho salmon, spring chinook salmon, steelhead. Sockeye salmon were extirpated upstream from Kachess Dam in 1904 by the construction of a crib dam. Currently the lake supports resident kokanee salmon, rainbow trout, cutthroat trout, bull trout, and burbot. Resident fishes, including bull trout, would have had year-round access into the lake. Lake level fluctuation and drawdown likely reduces production of phytoplankton, zooplankton and aquatic insects (USBR 2000a), which in turn reduces the prey base for bull trout and kokanee salmon residing in the reservoir. Bull trout overwinter in Kachess Lake (Haring 2001). The Kachess River upstream from the

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2 *Wenatchee Land and Resource Management Plan*. 1990. Wenatchee National Forest, Wenatchee, WA (as amended by *Northwest Forest Plan* of 1994, Region 6, Seattle, WA)

reservoir is dry near its confluence with Kachess Lake in late summer through late October, depending on fall precipitation, which may impact bull trout movement into the lake. Other species (coho salmon and spring chinook salmon) might also be impacted by this annual and temporary seasonal dewatering.

4.2.1 Salmonid species potentially benefitting from fish passage facilities at Kachess Lake

- Spring chinook salmon
- Coho salmon
- Sockeye salmon
- Steelhead
- Bull trout
- Mountain whitefish
- Rainbow trout
- Cutthroat trout
- Brook trout*
- kokanee salmon

** (asterisk) indicates species not native to the Yakima River basin*

4.2.2 Assessment of Kachess Lake tributary habitat conditions — Table B-4-3 summarizes the stream habitat that would be accessible to anadromous salmonids if passage were provided at Kachess Lake.

TABLE B-4-3. KACHESS LAKE TRIBUTARY STREAMS WITH HABITAT CONSIDERED SUITABLE FOR ANADROMOUS SALMONIDS

Tributary	Stream Habitat [miles (km)]		Comments
	Potentially accessible	Potentially available above manmade barriers	
Kachess River	0.5 (0.8)	0	Primary spawning stream
Box Canyon Creek	1.6 (2.57)	0	Primary spawning stream; natural barrier falls
Mineral Creek	0.25 (0.40)	0	Series of cascades blocks fish passage
Gale Creek	1.5 (2.4)	0	Barrier falls in third reach (about 1.5 miles upstream); in late summer, stream commonly goes subsurface in the lake bed and upstream
Thetis Creek	1.0 (1.6) based on map		In late summer, stream commonly goes subsurface in the lake bed and upstream
Total	**2.35 (3.76)**		

Notes: Since Gale Creek and Thetis Creek commonly go subsurface, they are not considered as being accessible to anadromous salmonids, and the overall tributary stream length is 2.35 miles. Other tributaries to Kachess Lake were considered too small or steep to support migratory fish.

4.2.3 Summary — If passage were provided for anadromous salmonids at Kachess Dam, about 2.35 miles of tributary habitat upstream from the lake would be accessible. Habitat quality in the several tributaries varies, due in some cases to substrate composition, water temperatures, or riparian or stream channel conditions that do not meet USFS Forest Plan standards. Spill of Kachess Lake down to elevation 2254 feet would encompass some of the period of volitional juvenile outmigration, with additional opportunity for volitional outmigration provided with a spill elevation down to elevation 2240 feet. However, the spill to elevation 2240 feet would provide additional coverage but generally not completely encompass the fall juvenile migratory period.

4.3 CLE ELUM LAKE

Cle Elum Lake is the largest of the four reservoirs in the Yakima Basin that once supported runs of anadromous salmonids. It was a natural lake that was first enlarged with a log crib dam in 1906. The present dam was constructed at RM 8 in 1933. The lake has an active storage capacity of 436,900 acre-feet and a surface area of 4,800 acres (USBR 1981). Before construction of the dam, the lake contained a variety of sport fish, including mountain whitefish, rainbow trout, cutthroat trout, bull trout, and burbot. Historically, sockeye salmon used the lake for rearing and, along with coho and chinook salmon, the streams above the lake for spawning (Robison 1957, Mongillo and Faulconer 1982; both cited in Flagg and Ruehle 2000). Resident fishes, including bull trout, would have had year-round access into the lake. Currently the lake supports resident kokanee salmon, rainbow trout, cutthroat trout, bull trout, lake trout, pygmy whitefish, and burbot.

The lake has a large and diverse watershed with numerous tributaries, three of which (the Cle Elum, Cooper, and Waptus Rivers) are thought to contain substantial potential spawning habitat for anadromous salmonids (Spotts 1981, cited in Slatick and Park 2000). Cle Elum Falls on the Cle Elum River at about RM 9 is a potential upstream barrier to fish passage. It may be passable by strong-swimming fish during high flows. The Cooper River has a barrier approximately 0.6 miles (1 km) upstream from Salmon la Sac, while Waptus Falls in the Alpine Lakes Wilderness Area is a barrier on the Waptus River.

Cle Elum Lake undergoes annual drawdown that seriously impacts the lake's littoral zone resulting in an extremely limited littoral biological community that is nearly devoid of benthic macroinvertebrates (Flagg et al. 2000). Benthic invertebrates have nearly been eliminated from the littoral zone due to water level fluctuations. Primary production is probably reduced in the lake compared to historic conditions, based on analysis of phosphorus in lake sediments and algal bioassay studies (Dey 2000 in Flagg et al. 2000).

4.3.1 Salmonid species potentially benefitting from fish passage facilities at Cle Elum Dam

- Spring chinook salmon
- Coho salmon
- Sockeye salmon
- Steelhead
- Bull trout
- Mountain whitefish
- Rainbow trout
- Cutthroat trout
- Brook trout*
- Kokanee salmon
- Brown trout*
- Lake trout*

** (asterisk) indicates species not native to the Yakima River basin*

4.3.2 Assessment of tributary habitat conditions — Table B-4-4 summarizes the stream habitat that would be accessible to anadromous salmonids if passage were provided at Cle Elum Lake.

TABLE B-4-4. CLE ELUM LAKE TRIBUTARY STREAMS WITH HABITAT CONSIDERED SUITABLE FOR MIGRATORY SALMONIDS			
	Stream habitat [miles (km)]		
Tributary Stream	**Potentially accessible**	**Potentially available above manmade barriers**	**Comments**
Cle Elum River	21.6 (34.8)		Steep cascades at RM 9 may limit upstream migration for some fish
Thorp Creek	0		Barrier cascades and high gradient in lower reach
Cooper River	0.6 (1)		Barrier falls
Waptus River	7.2 (11.5)		Impassable falls
Total	**29.4 (47.3)**		
Note: Other tributaries to Cle Elum Lake were considered too small or steep to support migratory fish.			

4.3.3 Summary — The determination of projected length of tributary streams potentially available upstream from Cle Elum Dam if fish passage were provided was complicated by the fact that the several reports available provided different estimates of the habitat potentially available in the Cle Elum River. For example, Flagg et al. (2000) reported that "Cle Elum falls" (considered by local fisheries biologists as a series of cascades), about 9 miles upstream from the full pool end of the reservoir, would block adult fish migration under many water flow conditions. However, Haring (2001) stated that migratory fish would have access to 18.4 miles of Cle Elum River habitat up to Hyas Lake, and Croci (FWS, Yakima, WA, pers. comm., 2002) reported available Cle Elum River stream length as 21.6 miles, if passage for anadromous fish were provided at Cle Elum Dam. If passage were provided for anadromous salmonids at Cle Elum Dam, about 29.4 miles of tributary habitat upstream from Cle Elum Lake would be accessible. Habitat quality in the several tributaries varies, due in some cases to substrate composition, water temperatures, or riparian or stream channel conditions that do not meet USFS Forest Plan standards. Spill of Cle Elum Lake down to elevation 2223 feet would encompass the period of most volitional juvenile outmigration, with some additional coverage provided with a spill elevation down to elevation 2190 feet. Spill to elevation 2190 feet would provide additional opportunities for volitional juvenile passage, but in some years would not entirely overlap the juvenile fall migratory period (see Figure 3 in Appendix D).

Flagg et al. (2000) reported that the Cle Elum, Cooper, and Waptus rivers contain substantial potential spawning habitat for anadromous salmonids. Habitat in these rivers could support tens of thousands of returning salmonids. The extreme fill/spill cycle of Cle Elum Lake poses substantial challenges for outmigrating juvenile salmonids, especially sockeye salmon during the early spring (late March-early May) outmigration season. Once past Cle Elum Dam, outmigrating juvenile salmonids would not encounter migration obstacles in the Yakima River, although they could be affected by irrigation diversions.

An "Ecosystem Diagnosis and Treatment" (EDT) simulation estimated that the headwaters area in the Cle Elum River would be capable of sustaining a spawning population of 328 spring chinook salmon, with a productivity of 2.7 adults progeny per spawner (Haring 2001).

4.4 BUMPING LAKE

Bumping Dam is located in the Snoqualmie National Forest in Yakima County about 29 miles northwest from Naches, Washington. The dam was constructed at the lower end of a natural lake between 1909 and 1910 at RM 15.7 on the Bumping River in order to provide water for irrigation, recreation, flood control, and fish and wildlife purposes. The dam is an earth-fill structure with a height of 61 feet, a hydraulic height of 36 feet, and a crest length of 2,925 feet. Some Safety of Dams modifications were made between 1994 and 1997. Bumping Reservoir has a drainage area of about 68 square miles, with an active conservation capacity of about 33,700 acre-feet (USBR 1981).

4.4.1 Salmonid species potentially benefitting from fish passage facilities at Bumping Lake Dam

- Spring chinook salmon
- Coho salmon
- Sockeye salmon
- Steelhead
- Bull trout
- Mountain whitefish
- Rainbow trout
- Cutthroat trout
- Brook trout*
- Kokanee salmon

** (asterisk) indicates species not native to the Yakima River basin*

4.4.2 Assessment of tributary habitat conditions — Table B-4-5 summarizes the stream habitat that would be accessible to anadromous salmonids if passage were provided at Bumping Lake.

TABLE B-4-5. BUMPING LAKE TRIBUTARY STREAMS WITH HABITAT CONSIDERED SUITABLE FOR MIGRATORY SALMONIDS

Tributary Stream	Stream habitat [miles (km)]		Comments
	Potentially accessible	Potentially available above manmade barriers	
Bumping River	1.0 (1.6)		Waterfall limits upstream migration (USFS 1995)
Deep Creek	5-5.6 (8-9.28)		Lower 0.5 miles goes subsurface in low water years
Total	**6-6.6 (9-10.88)**		
Note: Other tributaries to Bumping Lake were considered too small or steep to support migratory fish			

4.4.3 Summary — If passage were provided for anadromous salmonids at Bumping Dam, about 6 miles of accessible tributary habitat would be provided upstream from Bumping Lake. Habitat quality in the several tributaries varies, due in some cases to substrate composition, water temperatures, or riparian or stream channel conditions that do not meet Forest Plan standards. Based on a surface spill elevation of

Bumping Lake for water years 1994-2001, spill of Bumping Lake down to elevation 3420 feet (the elevation of the existing spillway) would provide a limited period of volitional passage of juvenile fish. As noted above, spill to elevation 3420 feet would not entirely or in some cases even partially overlap the fall juvenile migratory period (see Figure 4 in Appendix D).

4.5 RIMROCK LAKE (Tieton Dam)

Tieton Dam is located in the Snoqualmie National Forest in Yakima County about 40 miles northwest from Yakima, Washington. It was constructed between 1917 and 1925 at RM 21.3 on the Tieton River to provide water for irrigation, recreation, flood control, and fish and wildlife purposes. It is an earth-fill structure with a concrete core wall, a height of 319 feet, a hydraulic height of 198 feet, and a crest length of 920 feet. The reservoir, Rimrock Lake, has a drainage area of about 186 square miles. Clear Lake Dam is located on the North Fork Tieton River about 8 miles upstream from Tieton Dam. The drainage area upstream from Clear Lake Dam is about 58 square miles. The drainage area between Clear Lake Dam and Tieton Dam is about 128 square miles. Rimrock Lake has an active storage capacity of 198,000 acre-feet, with a surcharge capacity of 5,600 acre-feet (USBR 1981).

The dam does not have fish passage facilities and is a barrier to fish migration. It precludes access to 1.5 miles of the Tieton River, about 22 miles of the North Fork Tieton River, about 4 miles of the North Fork tributaries of Clear Creek and Indian Creek, and about 13.5 miles of the South Fork Tieton River (Haring 2001). An EDT analysis estimated that this area is capable of sustaining a spawning population of 350 spring chinook salmon, with a productivity of 3.8 adult progeny per spawner.

The Yakima-Tieton Diversion Dam at RM 14.2 is also a barrier to upstream fish migration at low flows (WDFW 1998, cited in Haring 2001). There is some ongoing work to improve fish passage at this dam.

Clear Creek Dam upstream on the North Fork Tieton River has a fish ladder, but it is apparently ineffective in providing passage for bull trout.

4.5.1 Salmonid species potentially benefitting from fish passage facilities at Rimrock Lake

- Spring chinook salmon
- Coho salmon
- Sockeye salmon
- Steelhead
- Bull trout
- Mountain whitefish
- Rainbow trout
- Cutthroat trout
- Brook trout*
- Kokanee salmon

** (asterisk) indicates species not native to the Yakima River basin*

4.5.2 Assessment of tributary habitat conditions — Table B-4-6 summarizes the stream habitat that would be accessible to anadromous salmonids if passage were provided at Rimrock Lake.

TABLE B-4-6. RIMROCK LAKE TRIBUTARY STREAMS WITH HABITAT CONSIDERED SUITABLE FOR MIGRATORY SALMONIDS			
Tributary Stream	**Stream habitat** [miles (km)]		**Comments**
	Potentially accessible	**Potentially available above manmade barriers**	
South Fork Tieton River	13.5 (21.6)		Falls at 13.5 mi. limits upstream migration
Short and Dirty Creek	0.1 (0.16)	0	Natural barrier limits upstream migration
Corral Creek	2.2 (3.5)		Falls at 2.2 mi. limits upstream migration
Bear Creek (SF Tieton)	0.5 (0.8)		Natural barrier limits upstream migration
Bear Creek (Rimrock)	3.7 (5.9)		High sedimentation
NF Tieton River	9.9 (15.9)		Falls at 9.9 mi. limit upstream migration
Clear Creek	2 (3.2)		Barrier falls limit upstream migration
Indian Creek	4.9 (7.8)		Falls at 4.9 miles limit upstream migration
Total	**36.8 (59)**		
Note: Other tributaries to Rimrock Lake were considered too small or steep to support migratory fish			

4.5.3 Summary — If passage were provided for anadromous salmonids at Tieton Dam, potentially accessible habitat in tributaries upstream from Rimrock Lake amounts to about 36.8 miles, out of a total of at least 50 miles in the selected tributaries. Habitat quality in the several tributaries varies, due in some cases to substrate composition, water temperatures, or riparian or stream channel conditions that do not meet USFS Forest Plan standards. Based on a surface spill elevation of Rimrock Lake for water years 1994-2001, spill of Rimrock Lake down to elevation 2918 feet (the elevation of the existing spillway) would provide a limited period of volitional passage of juvenile fish. Increasing spill to elevation 2900 feet would provide additional volitional juvenile fish passage in most years but would not encompass the entire fall juvenile migratory period (see Figure 5 in Appendix D).

B-5. SALMONID BIOLOGY AND LOCAL LIFE HISTORY

5.1 SPRING CHINOOK SALMON

Adult spring chinook salmon return to the upper mainstem Yakima River beginning in May. Adults migrate close to the area where they will spawn and find a place to hold in cover (deep water with woody debris or undercut banks or both) until they spawn in September and October. Depending upon water temperature, the peak of spawning may occur from September 15 to October 1 (NPPC 2001). Most spawning now occurs in the mainstem Yakima River between the Teanaway River and Easton Dam. There are also many adults that spawn in the Cle Elum River and in the Yakima River between the town of Thorp and the Teanaway River. Adults that spawn in the upper reaches of tributaries typically move into the tributaries by the end of June or early July when flows are still high enough for them to traverse the lower reaches of the tributaries (McMichaels, Battelle Pacific Northwest Laboratories, Richland, WA, pers. comm.). Some migrating adult fish will arrive early prior to the time some streams go subsurface to make it past the parts of the streams that eventually go dry for a period of time. Variability in run timing is influenced by high and low flows. Run-timing for spawning runs of all salmon and steelhead is delayed during years of high flow and accelerated in years of low flow.

Naches River spring chinook salmon usually begins spawning in late August, while the upper mainstem Yakima River stock usually begins spawning in early September. The peak of spawning activity for spring chinook salmon in the Naches River ranges from September 8 to September 18 and in the upper mainstem Yakima River from September 15 to October 1 (Fast et al. 1991).

Spring chinook salmon emerge from the gravel in March-May and use slow-water habitat near the edges of the river. Emergence appears to be quite closely synchronized across stocks of spring chinook salmon despite 5 to 7 weeks differences in spawning timing. In the upper Yakima River, fry were captured between March 8 and June 13, with a median capture date of April 16.

Fry from all stocks redistribute themselves downstream the spring and summer after emergence, with highest densities in summer being found well below the major spawning areas, but above Sunnyside Diversion Dam (RM 103.8). The lack of anadromous salmonids rearing in the lower Yakima River is attributed to excessive summertime water temperatures in the mainstem below Sunnyside Diversion Dam (Fast et al. 1991). In some cases juveniles rear in the general area where they were spawned while others migrate up tributary streams to rear for the summer. Upstream juvenile migrations into tributaries for early rearing have been documented in numerous tributaries (NPPC 2001).

All Yakima River stocks of spring chinook salmon exhibit an extensive downstream migration of pre-smolts in the late fall and early winter (Pearsons et al. 1996) Most juvenile spring chinook salmon in the Upper Yakima Basin migrate down river during the fall-winter period and overwinter in the Yakima River somewhere between Roza and Prosser dams (probably in the Zillah/Granger area). This “winter migrant” behavior is presumably triggered by rapidly falling water temperatures in the late fall. This thermal trigger occurs earlier in the upper reaches of the basin. Although 10-35 percent of the juveniles from a given brood year migrate below Prosser Dam (RM 47.1) during the winter, most fish overwinter in the deep slackwater reach of the Yakima River between Marion Drain (RM 82.6) and Prosser Dam (Fast et al. 1991); they begin their smolt outmigration from the lower river the following spring. This “winter migrant” behavior for all wild Yakima spring chinook salmon is contrasted with an "upriver smolt" type, which spend the winter in the upper Yakima system in the mainstem and in tributaries like Badger and Wilson creeks, much closer to natal areas, then outmigrate as smolts during the following spring (NPPC 2001).

The outmigration timing of Yakima River spring chinook salmon smolts is also quite variable. The overall timing of the outmigration does not appear to be shifted earlier or later by flow, although the migration rate of actively migrating smolts is positively correlated with flow. The gross timing of the outmigration seems instead to be a function of water temperature the winter preceding smoltification. Specifically, there is an inverse relationship between the mean outmigration date and the thermal units accumulated over the months of December through March: the more degree-days in the Yakima River through the coldest part of winter, the earlier the outmigration, and vice versa (NPPC 2001).

Studies of radiotagged spring chinook salmon adults released below Prosser Dam in 1991-1992 and monitored through spawning, indicated that there was no interstock difference in the temporal distribution of fish as they arrived at Prosser Dam (Hockersmith et al. 1994). This was true even though there were clear interstock differences in the onset and duration of spawning.

In an EDT analysis of spring chinook salmon in the upper Yakima River basin, parr, wintering parr, and fry were determined to be the most severely impacted life stages, in descending order (NPPC 2001). The most significant environmental impacts in descending order were habitat complexity, flow, and key habitat (NPPC 2001). Although this analysis was for spring chinook salmon downstream from dams, it is reasonable to expect these same life stages and environmental impacts to be the most impacted or significant in tributaries upstream from Yakima Basin reservoirs. *Yakima Subbasin Summary* (NPPC 2001) and Haring (2001) provide additional migration and life history information and a review of passage timing and other information.

5.2 COHO SALMON

All upper Columbia River coho salmon stocks, including those in the Yakima River, are believed to be extinct; endemic coho salmon were extirpated in the early 1980s (NPPC 2001). Beginning in the 1950s and continuing through the 1970s, an extensive network of coho salmon hatcheries was constructed in the lower Columbia River. Fish management agencies allowed harvest rates of 80-90 percent. Although the hatchery runs of coho salmon could withstand such high rates of harvest, wild Columbia River coho salmon stocks were also harvested in the mixed-stock fisheries. As a result of hatchery, harvest, and loss of habitat, most Columbia River coho salmon stocks above Bonneville Dam were lost (Johnson 1991).

Natural reproduction of hatchery-reared coho salmon, outplanted as smolts, is now occurring in the Yakima River and the Naches River. Natural reproduction is evident from the increasing occurrence of age-zero coho salmon parr in samples collected at numerous points in the basin (Yakama Nation, unpublished data, 2000). Coho salmon currently returning to the basin are a mix of hatchery stocks from outside the basin. Efforts are underway to develop a "naturalized" stock. Currently coho salmon enter the Yakima River in the fall and reach the upper watersheds in November and December. Adult passage data at Roza Dam from 1941-1968 indicate that the endemic coho salmon run timing was earlier than now. The vast majority of the hatchery coho salmon smolts outplanted since 1985 have also been early-run. There is also some evidence for a bimodal distribution in the run timing of coho salmon (Pat Monk, fishery biologist, Yakima Basin Joint Board, Ellensburg, WA, October 2002, pers. comm.)

Based on sparse WDFW records of spawner surveys, the endemic stock spawned in the upper Yakima River above the Cle Elum River confluence and in the Naches River, primarily in the lower alluvial reaches downstream from the Tieton River confluence. Bryant and Parkhurst (1950) reported that coho salmon also spawned in smaller tributaries of the upper Yakima, such as Taneum and Umtanum Creeks, in the early years of the 20th century, and affidavits from early settlers of the Wenatchee basin state that “silvers” were found in virtually every perennial creek and river in the basin before extensive development occurred. It is now assumed that coho salmon utilized virtually every low-gradient perennial stream in the basin prior to the extensive habitat alteration that began in the late 19th century (YIN 1990).

Efforts to restore coho salmon within the Yakima Basin rely largely upon releases of hatchery-produced fish. The Yakama Nation has released between 85,000 and 1.4 million coho salmon smolts in the Yakima Basin annually since 1985. However, before 1995, the primary purpose of these releases was harvest augmentation; after 1995, the primary purpose became a test of the feasibility of re-establishing natural production (NPPC 2001).

The current, naturalized run spawns in reaches downstream from the historical areas because, until 1999, the vast majority of hatchery smolts were acclimated and/or released well downstream from historical spawning areas. Radiotag monitoring of adult coho salmon in the fall of 1999 indicated that most coho salmon now spawn in proximity to their acclimation and release points, primarily in the middle Yakima below Sunnyside Diversion Dam, from RM 95 to RM 104 (Dunnigan 2000). In recent years, coho salmon spawning has been documented in side channels of the mainstem Yakima River between Roza Dam and the town of Wapato (about RM 100) and in the Yakima Canyon (RM 129 to RM 146); in Naches River below the Tieton River confluence; and in numerous smaller tributaries.

McNeil and Kreeger (1993) and Yakama Indian Nation (1990) estimated the historical coho salmon run at 44,000 and 150,000 fish, respectively. Coho salmon returns since regular outplanting began in 1985 have increased steadily, climbing from 0 in 1984 to a peak of 5,700 in 2000. Few of the outplanted coho salmon were marked until recently. Therefore, the proportion of natural origin recruits in recent returns is unknown.

The spawning distribution and spawning success of coho salmon returning to the Yakima River is just beginning to be determined (NPPC 2001). Earlier attempts to determine the spatial distribution of spawning coho salmon in the Yakima was compromised by difficulty in finding redds. An indication of the problem is the 25:1 ratio of adults passing Prosser Dam to redds counted later in the season during the period 1989-1996. Thus, assuming a 50 percent sex ratio, only about 8 percent of the potential redds were discovered (YN 1997).

A 3-year radiotelemetry study was initiated in 1999 to determine the spawning distribution of coho salmon in the Yakima Basin (NPPC 2001). Most coho salmon homed back to the general vicinity of the three lowest acclimation sites from which coho salmon smolts were released in the spring of 1998.

5.3 SOCKEYE SALMON

Before the unladdered crib dams were built (1904-1910) at the outlets of the four natural sockeye salmon rearing lakes, the sockeye salmon run was probably larger than any other in the Yakima Basin in terms of numerical abundance (YIN 1990). Prior to water development in the Yakima Basin, historic sockeye salmon run size has been "estimated" as 211,104 fish (YIN 1990). Historically, juvenile sockeye salmon reared in all of the headwaters lakes — Keechelus, Kachess, Cle Elum and Bumping — and adults probably spawned both in the lakes and lake tributaries.

Except for a handful of adult fish returning from experimental Cle Elum Lake research releases of hatchery-reared stock, smolts from Lake Wenatchee stock in the years 1991-1993 and 1995, and a number of experimental releases of smolts in the 1940s, sockeye salmon have not returned to the Yakima Basin since the1920s. Run-timing for sockeye salmon at Rock Island Dam and Rocky Reach Dam peaks in early-mid July, and the Lake Wenatchee adult sockeye salmon migration would peak about the same time.

Juvenile sockeye salmon rear exclusively in lakes, rather than streams as do other Pacific salmon species. Sockeye salmon also exhibit unique spawning behavior. Some populations of adult sockeye salmon spawn in lakes or in tributaries entering lakes. Other populations spawn in rivers flowing out of the lakes, downstream from the lake outlet. Upon emergence, sockeye salmon fry in lake-outlet spawning populations must migrate upstream in order to utilize the rearing habitat in the lake, whereas fry emerging from lake-inlet streams must migrate downstream to the rearing habitat in the lake. The direction sockeye salmon fry migrate is genetically based and is an important consideration for fish passage and hatchery supplementation (Burgner 1991).

5.4 STEELHEAD

5.4.1 Abundance and Distribution — Yakima Basin steelhead are a component of the NMFS-designated Middle Columbia River (MCR) steelhead Evolutionarily Significant Unit (ESU). Adult steelhead return to the upper Yakima River between September and May. Current steelhead abundance is only about 1.3 to 6 percent of historical estimates, averaging 1,256 fish over the brood years 1985 to 2000 (NPPC 2001). Numbers of adults returning above Roza Dam has been very low until about the past 10 years (about 100 to 200 steelhead per year). About 7 percent of the basin-wide steelhead run goes past Roza Dam (Walt larrick, USBR Yakima, February 2003, pers. comm.).

The MCR steelhead ESU was listed as threatened under the Endangered Species Act (ESA) on March 25, 1999 (64 Fed. Reg. 14517). It includes all natural-origin populations in the Columbia River Basin above the Wind River, Washington, and the Hood River, Oregon, including the Yakima River. This ESU includes the only populations of winter inland steelhead in the United States (in the Klickitat River, Washington, and Fifteenmile Creek, Oregon). Both the Deschutes River and Umatilla River hatchery stocks are included in the ESU, but are not listed. Critical habitat is not presently designated for MCR steelhead.

Middle Columbia River steelhead population sizes are substantially lower than historic levels, and at least two extinctions are known to have occurred in the ESU. Based on historic (pre-1960s) estimates, the run size could have been in excess of 300,000 fish (Busby et al. 1996). In recent years, wild fish escapement among the ESU populations has averaged 39,000 and total escapement 142,000. A large proportion of hatchery fish, concurrent with the decline of wild fish, is a major risk to the MCR steelhead ESU (WDFW et al. 1993; Busby et al. 1996; 63 Fed. Reg. 11798, March 10, 1998).

Across the entire ESU, steelhead abundance in larger rivers like the Yakima has also been severely reduced. It is estimated that the Yakima River had annual run sizes from 20,000 to 100,000 steelhead prior to development (WDF et al. 1993). Although historical run size estimates vary, numerous early surveyors and visitors to the Yakima Basin reported a robust and widespread steelhead population (Bryant and Parkhurst 1950; Davidson 1953; Fulton 1970; NPPC 1986; McIntosh et al. 1990).

Within the Yakima River basin, wild adult steelhead returns have averaged 1,488 fish (low of 505 in 1996 to high of 4,461 in 2002) over brood years 1985-2002 as monitored at Prosser Dam (NPPC 2001; brood year 2002 data from Yakima-Klickitat Fisheries Program [YKFP], available at www.ykfp.org). YKFP data showed that 1,362 wild adult steelhead had passed Prosser Dam as of January 7, 2003. This comparatively large return mirrors high numbers of returning salmon and steelhead observed returning to the Columbia basin in the past two years.

5.4.2 Factors for Decline — Several factors have been noted for contributing to the decline of steelhead in the upper mainstem Yakima River basin. These include structural simplification of most of the anastomosing reaches of the mainstem Yakima River, partial or complete blockage of spawning tributaries by irrigation diversion dams, entrainment of smolts in tributary and mainstem irrigation diversions, the release of large volumes of water from storage reservoirs in the summer when steelhead fry are just emerging, and stranding of fry and parr in shallow side channels. For many years, operation of Roza Dam precluded fish access to the ladder during the time period steelhead return to the basin.

5.4.3 Migration and Spawning — Generally, adult MCR steelhead migration into the Yakima Basin peaks in late-October and again from late February or early March. Steelhead adults begin passing Prosser Dam in late summer, suspend movement during the colder parts of December and January, and resume migration from February through June. The relative number and timing of wild adult steelhead returning during the fall and winter-spring migration periods varies from year to year, most likely because of a low-flow induced thermal barrier in the lower Yakima River in the fall (USBR 2000a; NPPC 2001). Most adult steelhead overwinter in the Yakima River between Prosser Dam (RM 47.1) and Sunnyside Diversion Dam (RM 103.8) before moving upstream into tributary or mainstem spawning areas (Hockersmith et al. 1995).

Steelhead spawning varies across temporal and spatial scales in the Yakima Basin, although the current spatial distribution is significantly decreased from historic conditions. Yakima Basin steelhead spawn in intermittent streams, mainstem and side-channel areas of larger rivers, and in perennial streams up to relatively steep gradients (Hockersmith *et al.* 1995; Pearsons *et al.* 1996). Hockersmith *et al.* (1995) identified eleven spawning populations within the Yakima Basin:

- upper Yakima River above Ellensburg
- Teanaway River
- Swauk Creek
- Taneum Creek
- Roza Canyon
- mainstem Yakima River between the Naches River and Roza Dam
- Little Naches River
- Bumping River
- Naches River
- Rattlesnake Creek
- Toppenish Creek
- Marion Drain
- Satus Creek

Of 105 radiotagged fish observed from 1990 to 1992, Hockersmith et al. (1995) found that well over half of the spawning occurs in Satus and Toppenish Creeks (59 percent). A smaller proportion was found in the Naches drainage (32 percent), and the remainder in the mainstem Yakima River below Wapato Dam (4 percent), mainstem Yakima River above Roza Dam (3 percent), and Marion Drain (2 percent), the latter a

Wapato Irrigation Project drain tributary to the Yakima River. Electrophoretic analyses have identified four genetically distinct spawning populations of wild steelhead in the Yakima Basin: the Naches, Satus, Toppenish, and Upper Yakima stocks (Phelps et al. 2000).

Typically, steelhead spawn earlier in lower-elevation warmer waters than in higher-elevation colder waters. Overall, most spawning is completed within the months of January through May (Hockersmith et al. 1995), although WDFW personnel have observed steelhead spawning in July in the Teanaway River (RM 176.1), a tributary to the upper arm of the Yakima River. These steelhead spawn later in the year at higher elevations in the Yakima Basin, and face lethal conditions (in most years) as emigrating kelts (spawned-out adults returning to the ocean) in the lower Yakima River. MCR steelhead that spawn in the Yakima Basin at lower elevations potentially meet the same fate, however earlier spawn timing and emigration may provide increased survival because kelts traverse the lower Yakima River before water quality becomes lethal. High water temperatures, low flows, and degraded water quality from irrigation effluents (a combination of high water temperature, turbidity and pollutant concentrations), contribute to extremely low survival during summer months (Vaccaro 1986; Lichatowich and Mobrand 1995; Lichatowich et al. 1995; Pearsons et al. 1996; Lilga 1998). Steelhead kelts and smolts have been observed at the Chandler Juvenile Enumeration Facility (about ½-mile downstream from Prosser Dam) into the middle of July, but operations at this facility cease around this time because river conditions prove lethal for most salmonids (including smolt, juvenile, and kelt MCR steelhead). Conditions in the lower Yakima River become suitable once again for salmonids in early fall, near the end of the irrigation season (NPPC 2001).

Most Yakima River basin steelhead are tributary spawners, with most currently spawning in the complex, multi-channel reaches of tributaries with a "moderate" gradient, about 1-4 percent (NPPC 2001), such as Naches River and tributaries, Satus Creek or Toppenish Creek.

Steelhead spawning has been documented throughout the mainstem Yakima River and especially between the mouth of the Yakima Canyon and Ellensburg, in the Bristol Flats area to around the mouth of the Teanaway River, and in the area between Easton Dam and the mouth of Big Creek. Steelhead spawning has also been documented in Umtanum, Cherry, Taneum, and Swauk creeks as well as in the West and North forks of the Teanaway River.

Adult steelhead spawn during the spring/early summer period between March and July. As nearly as can be determined, spawning occurs in the middle Yakima River (the reach between Roza Dam and Sunnyside Diversion Dam), the upper main Yakima River and higher elevation upper Yakima River tributaries according to the following approximate schedule (NPPC 2001):

- **middle Yakima River** — late February through early April, peak in late March
- **upper Yakima River mainstem in Yakima Canyon** (including Umtanum and Wilson/Naneum Creeks) — late March to mid May with a peak in late April,
- **upper Yakima River mainstem above the Yakima Canyon** — from mid April to late May with a peak in early May
- **upper Yakima River tributaries** (Big Creek, Teanaway River, Swauk Creek, Taneum Creek, Manastash Creek) — late April through early June, with a peak in late May.

Juvenile steelhead emerge from the gravel between June and August and rear in the areas near where they were spawned. Much less is known about the life cycle of juvenile steelhead in the Yakima River system than for chinook salmon for two reasons; 1) the steelhead are much less abundant, and 2) juvenile steelhead are indistinguishable from resident rainbow trout until they reach the smolt stage.

Juvenile steelhead utilize tributary and mainstem reaches throughout the Yakima Basin as rearing habitat until they begin to smolt and emigrate from the basin. Smolt emigration begins in November, peaking between mid-April and May. Busack et al. (1991) analyzed scale samples from smolts and adult steelhead. They found that smoltification generally occurs after 2 years in the Yakima system, with a few fish maturing after 3 years and an even smaller proportion reaching the smolt stage after one year. When compared to spawning distribution and run timing, these data suggest that various life stages of listed steelhead are present throughout the Yakima Basin and its tributaries virtually every day of the calendar year.

Steelhead smolts have been collected in mainstem Yakima River, all three forks of the Teanaway River, and Swauk, Taneum, Manastash, Dry, Wilson, Naneum, Cherry, Badger, and Umtanum creeks. Steelhead in other streams that are similar to the Yakima River (that is, those in the Deschutes River, Oregon, which are also part of the MCR steelhead ESU) can spawn in small and relatively warm tributaries; some fish even spawn in seasonally intermittent tributaries. Most steelhead smolts migrate from the Yakima River between the ages of 1 and 3, although in some systems steelhead may rear in freshwater for 1 to 7 years before smolting and beginning their seaward migration.

The Upper Yakima River steelhead population was undoubtedly adversely affected by operations at Roza Dam (RM 128) between 1939 and 1958 (USBR 2000a). Although fitted with a ladder, the pool at Roza Dam was kept down from the end of one irrigation season (mid-October) to the beginning of the next (mid-March) during this 20-year period. Hockersmith et al. (1995) found that steelhead passed Roza Dam from November through March, and more recent data suggest that passage occurs from the end of September through May (see www.ykfp.org). Consequently, operations at Roza Dam virtually eliminated fish passage for most of the steelhead migration season and excluded most steelhead bound for the upper Yakima from reaching their destination. A new ladder was installed at Roza Dam in 1989 that allows better passage, but only when the pool is completely up or down. However, the ladder is inoperable at levels between maximum and minimum pool when the reservoir is manipulated to facilitate screen maintenance at the end of October and early November. Additionally, as previously described, MCR steelhead spawn and emergence timing is shifted to later in the year in the Upper Yakima, and emigrating smolts therefore meet hazardous if not lethal water quality conditions in the lower Yakima River. This combination of historic and contemporary seasonal factors could help explain in part the low abundance of MCR steelhead in the Upper Yakima Basin.

Pre-smolt rearing migrations are less well understood for steelhead than they are for spring chinook salmon. The presence of juvenile steelhead in small tributaries throughout the summer, sometimes in high densities, indicates that the fish are apparently less inclined to migrate downstream for early rearing than spring chinook salmon (NPPC 2001).

Yakima Subbasin Summary (NPPC 2001) raises some interesting questions and provides discussion regarding eventual restoration of steelhead populations in the upper Yakima River in light sympatric populations of resident rainbow trout and complex life history attributes of the two ecotypes, including reproductive isolation or the lack thereof. Zimmerman and Reeves (2000) provide additional information on reproductive isolation of steelhead and resident rainbow trout.

5.5 BULL TROUT

5.5.1 Distribution and Status — Bull trout (*Salvelinus confluentus*) occurred historically throughout most of the Yakima Basin. Today, however, they are fragmented into relatively isolated stocks. Although bull trout were probably never as abundant as other salmonids in the Yakima Basin due in part to their requirements for cold, clear water, they were certainly more abundant and more widely distributed than they are today (WDFW 1998).

In June 1998, the U.S. Fish and Wildlife Service (FWS) listed the Columbia River basin “distinct population segment” of bull trout as threatened under the Endangered Species Act (63 Fed. Reg. 31647;

10 June 1998). FWS identified eight bull trout subpopulations in the Yakima River basin in its 1998 final listing rule (63 FR 31647). These subpopulations included:

- Ahtanum Creek
- Naches River
- Rimrock Lake
- Bumping Lake
- North Fork Teanaway River
- Cle Elum Lake
- Kachess Lake
- Keechelus Lake

At the time of listing, only the Rimrock Lake subpopulation was considered stable. The remaining subpopulations were classified as "depressed" and "declining." The population status for the Naches River subpopulation was classified as "unknown." With the exceptions of Rimrock Lake and the Naches River, the remaining subpopulations were considered to be at risk of extirpation.

WDFW recognizes nine bull trout stocks in the Yakima River basin (see table B-5-1 below). These stocks are consistent with the subpopulations identified by FWS in its final listing rule; however, it includes one stock (Yakima River) that was not recognized by FWS at the time of listing.[3/] Six stocks are classified as "critical" by WDFW, one is "depressed," one is "healthy," and one is "unknown" (classification definitions are in table B-5-1). The status of each of these stocks was largely derived from redd counts that WDFW has been conducting on an annual basis since 1984.

Within each stock one or more local populations may exist. A local population represents a group of bull trout that spawn within a particular stream or portion of a stream system. Thus, a local population could be considered the smallest group of fish that represent an interacting reproductive unit. Gene flow may occur between local populations but is assumed to be infrequent compared to that among individuals within a local population. There are presently thirteen local populations that have been identified in the Yakima River basin. Other local populations may exist but are as yet unrecognized. For example, as recently as the summer of 2002, a juvenile bull trout was captured by Yakama Nation fisheries personnel in a tributary to Cowiche Creek (Eric Anderson, WDFW, pers. comm., June 2002).

3 This exclusion was due to a lack of information which has since been attained.

Table B-5-1. Yakima River basin bull trout stocks recognized by WDFW (from WDFW 1998).			
Stock	**Life History Form**	**Status**	**Comments**
Keechelus Lake	adfluvial	Critical	Chronically low redd counts
Kachess Lake	adfluvial	Critical	Chronically low redd counts
Cle Elum/Waptus Lakes	adfluvial	unknown	
Bumping Lake	adfluvial	Depressed	Short-term severe pop. declines
Rimrock Lake	adfluvial	Healthy	
N. Fork Teanaway River	fluvial/resident	Critical	Chronically low redd counts
Naches River	fluvial/resident	Critical	Chronically low redd counts
Yakima River[1/]	fluvial	Critical	Chronically low redd counts
Ahtanum Creek	resident	Critical	Chronically low redd counts

[1/] Stock not recognized by FWS as subpopulation in its 1998 Final Listing Rule (63 FR 31647)

Critical — A stock of fish experiencing production levels that are so low that permanent damage to the stock is likely or has already occurred.
Depressed — A stock of fish whose production is below expected levels based on available habitat and natural variations in survival rates, but above the level where permanent damage to the stock is likely.
Healthy — A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.
Unknown — There is insufficient information to rate stock status.

5.5.2 Life History — Three bull trout life history forms are present in the Yakima Basin: adfluvial, fluvial and resident. Adfluvial and fluvial fish reside in lakes and mainstem rivers, respectively. Fry and juveniles rear in their natal streams for 1-4 years before migrating downstream into lakes or mainstem river systems. Adults migrate into tributary streams to spawn, after which they return to the lake or river. The resident life-history form resides in a particular stream for its entire life cycle. The life history forms displayed by each of the nine bull trout stocks in the Yakima Basin is presented in Table B-5-1. Adfluvial stocks occur in Rimrock, Bumping, Kachess, Keechelus and Cle Elum/Waptus lakes. A fluvial stock is present in the mainstem Yakima River, fluvial/resident forms are present in the Naches River and North Fork Teanaway River drainages, and a resident stock occurs in Ahtanum Creek (WDFW 1998).

Bull trout are late summer/early fall spawners and most spawning activity in the Yakima Basin, irrespective of life history form, occurs from early September through early October. However, spawning may occur as early as late August (Deep Creek in the Bumping system) or as late as mid-October to early November (Kachess River-Mineral Creek in the Kachess system). For the migratory life history forms, the spawning migration can begin as early as mid-July (Gold Creek in the Keechelus system) when adults move upstream to hold in deep pools or it may occur just prior to spawning (Indian Creek in the Rimrock Lake system).

The incubation period for bull trout is extremely long relative to other salmonids and fry may take up to 225 days to emerge from the gravel (Craig 1997). Adfluvial and fluvial juveniles will generally rear in their natal streams for 1-3 years before emigrating to their adult environments to further mature (Rieman and McIntyre 1993). Sexual maturity is reached in 5-7 years and the species may live up to 12 years, spawning repeatedly. Data from an adfluvial bull trout population in the Flathead Lake system of Montana indicate that between 38 to 69 percent of adults leave the lake each summer to spawn (Fraley and Shepard 1989). However, these are averages and some fish seem to spawn nearly every season, as evidenced by a female from Rimrock Lake that has spawned 5 of the past 6 years at Indian Creek (Paul James, Central Washington University, Ellensburg, WA, pers. comm.).

The primary downstream migration periods for juvenile bull trout from their natal tributaries into lakes or rivers occurs from June through November. The early summer migration appears to be in response to increased flows and may correspond with a switch in prey from invertebrates to fish, whereas the fall migration appears to be primarily in response to decreasing water temperatures and the need to find suitable overwintering habitat (Fraley and Shepard 1989; Murdoch 2002).

Relatively limited data exist on juvenile movement patterns downstream from lakes/reservoirs, or upstream into lakes/reservoirs from fluvial systems. However, it is likely these movements are triggered in response to shifts in food resources, temperature regimes, overwintering habitat or spawning activity or entrainment through dams, in which case the fish may be lost to the system if upstream passage is not provided. In the Lake Wenatchee system, Murdoch (2002) reported observing fish moving into the lake in the fall, apparently to overwinter. Further observations from traps downstream from Lake Wenatchee indicate juvenile bull trout are not frequently seen moving at this time of year in the fluvial environment.

5.5.3 Habitat — Bull trout appear to have unique habitat requirements. While migratory forms may use much of the river basin throughout their life cycle, spawning and rearing fish are often found only in a portion of the available stream reaches; rearing and resident fish often live only in smaller watersheds or second-to-fourth order tributaries (Armstrong and Morrow 1980; Fraley and Graham 1981; Platts 1974; Platts and Partridge 1983; Thurow 1987; Ziller 1992). Among the most important habitat attributes affecting bull trout distribution and abundance are suitable water temperatures, channel stability, clean substrates, adequate cover, and the presence of migration corridors (Allan 1980; Fraley and Graham 1981; Thurow 1987; Ziller 1992). Little is known regarding migration timing in the Yakima Basin.

Bull trout are extremely temperature sensitive. Water temperatures in excess of about 15 °C are thought to limit bull trout distribution (Allan 1980; Fraley and Shepard 1989; Goetz 1991; Pratt 1985; Shepard et al. 1984, Selong et al. 2001). Numerous studies have cited various temperatures as optimal for the different life stages of bull trout. Temperature data from archival temperature tags placed on adult bull trout in the summer of 2002 in the Wenatchee River system indicate maximum temperatures experienced were 15-16 ºC (De La Vergne 2002). In general, spawning is initiated when water temperatures drop below 10 °C. Optimal temperatures for incubation are between 2-4 °C, and those for rearing are in the range of 4-10 °C (Fraley and Shepard 1989; Goetz 1989; McPhail and Murray 1979).

Channel stability and clean substrates are closely associated habitat elements necessary for successful reproduction, fry and juvenile survival, and growth. As mentioned above, bull trout embryos and alevins spend an extended period of time beneath redd gravels. After emergence, young bull trout remain closely associated with stream channel substrates. The evidence suggests that channel instability and resultant increases in bedload movement and sediment deposition decreases bull trout survival (Goetz 1989; Weaver 1985). The species also demonstrates an affinity for complex forms of cover (woody debris, undercut banks, pools). Numerous studies have shown a positive correlation between bull trout densities and cover (Rieman and McIntyre 1993).

Open migratory corridors are essential to allow bull trout populations to move between seasonal habitats, exploit seasonal food resources, experience gene flow between populations, refound populations after local extirpations, and gain support from stronger populations. Disruption of migratory corridors will increase stress, reduce growth and survival, and possible lead to the loss of the migratory life-history types (Rieman and McIntyre 1993).

5.6 PACIFIC LAMPREY

5.6.1 Distribution and Status — Pacific lamprey (*Lampetra tridentata*) are currently recognized as a Category 2 candidate species as listed by FWS. Pacific lamprey are declining in most, if not all, areas of the Columbia River Basin (Close et al. 1995, 2002). In January 2003, a coalition of conservation groups petitioned FWS to list four species of lamprey (including the Pacific lamprey) as threatened or endangered. Historically, Native Americans fished for lamprey in the Yakima Basin, which suggests that they were quite abundant (Hunn 1990). The distribution of the two other species, river lamprey (*Lampetra ayresi*) and western brook lamprey (*Lampetra richardsoni*) is unknown in the Yakima Basin, however western brook lamprey have been found in the lower reaches of the Yakima River. Currently, lamprey are not harvested in the Yakima River because of their scarcity. Since so little information is available regarding lamprey abundance and distribution in the upper Yakima River basin and their ability to use fish passage facilities, these species will not be considered any further in this Phase I report.

5.6.2 Life History — Pacific lamprey spend the early part of their life burrowed in fine silt. After 4 to 6 years they undergo a metamorphosis that changes their physical appearance and physiological abilities. Juveniles then outmigrate to the ocean and spend between 20-40 months in a free swimming stage. Adults then return to their natal freshwater streams in June and July to spawn and die (Close et al. 2002; Wydoski and Whitney 1979). Unlike the other two species of lamprey, western brook lamprey spend their entire life in fresh water, and spawn from April through July with a peak in May.

5.6.3 Habitat — Although no historic records of lamprey above the Yakima River dams are known, there were several sightings just below the dams. WDFW Division of Non-Game Fish has a record of a river lamprey at the base of Easton Diversion Dam. There are also several reports by Todd Pearsons (WDFW, pers. comm.) of Pacific lamprey in the upper reaches of the mainstem Yakima River, but downstream from storage reservoirs. Juveniles typically rear in side channel areas of the mainstem of the Yakima River, and are often found in areas with well developed silt and aquatic plants.

5.6.4 Ecological Significance — Lampreys historically represented a significant percentage of the biomass in some streams and as such acted as important processors of stream nutrients. Lampreys also facilitate the processing of detritus and algae; they are poor digesters, thereby making this semi-digested material available to other aquatic organisms and enriching the aquatic ecosystem. Lamprey also act as a food source for other animals, including juvenile salmon (Pfeiffer and Pletcher 1964).

5.6.5 Cultural Significance — Traditionally, lamprey have been harvested by tribal peoples of the Columbia River Basin for subsistence, ceremonial, and medicinal purposes. They are important in celebrations (Close et al. 1995).

B-6. DATA DESCRIBING HABITAT CONDITIONS

6.1 KEECHELUS LAKE SUPPORT DATA

6.1.1 Meadow Creek — The *Yakima Watershed Assessment* (USFS 1999) reports three culverts on road crossings of Meadow Creek that exceed gradient criteria for fish passage design (located in T21N, R11E, Sections 8 and 16). The reaches sampled in Meadow Creek did not meet the *Northwest Forest Plan* (USFS 1994) standards for LWD presence or pool frequency (USFS 1997).

The standards are 100 pieces of large wood, 36 inches in diameter and 50 feet long; 100 pieces of small wood, 24 inches in diameter and 50 feet long; NMFS large-wood standard is 20 pieces of large wood. High water temperatures due to past logging likely preclude significant bull trout use until regrowth provides riparian shade.

Figures B-6-1 and B-6-2 show stream discharge and water temperature in Meadow Creek from early to mid June to late November.

Figure B-6-1. Meadow Creek discharges (cfs)

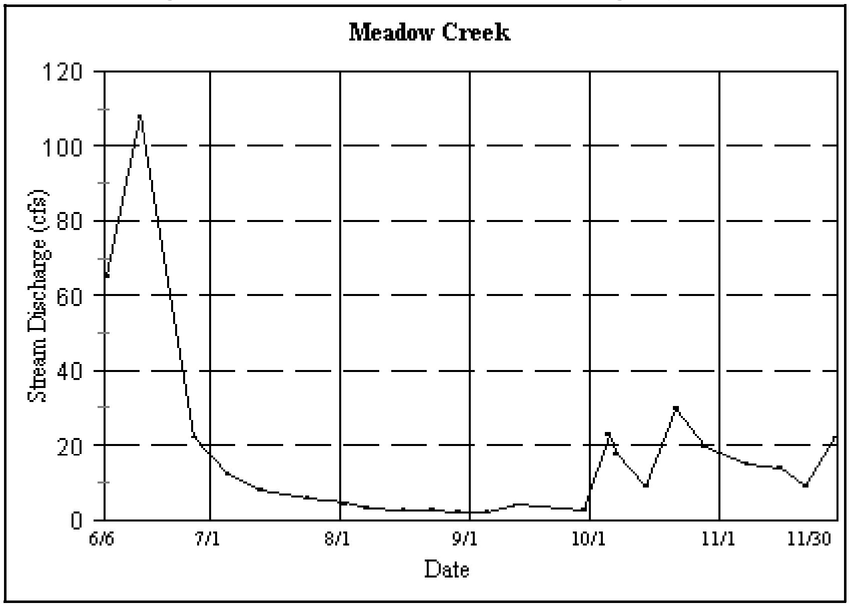
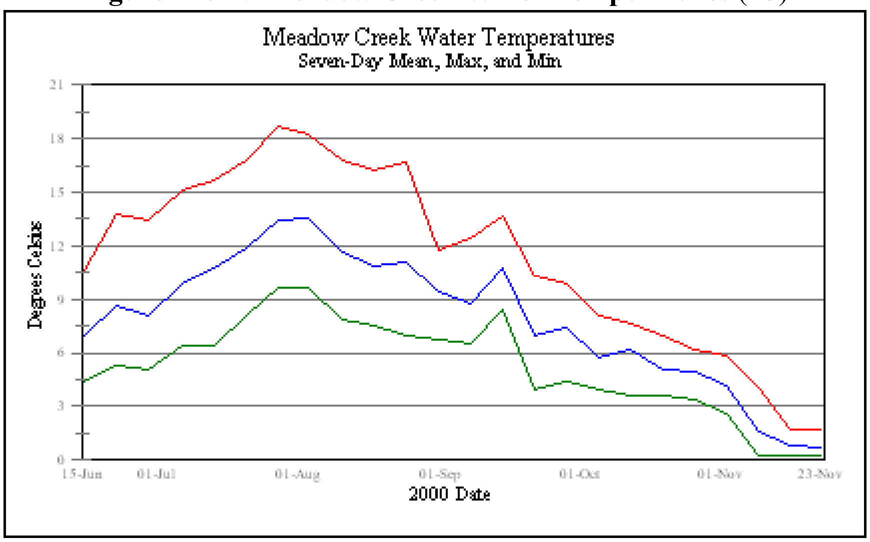


Figure B-6-2. Meadow Creek Water Temperatures (°C)



6.1.2 Gold Creek— Gold Creek has a natural falls at RM 7.1 that is a barrier to upstream fish passage (Craig 1997, cited in USBR 2000a). Adult bull trout migration into Gold Creek begins in mid to late July and continues into August until the creek becomes impassable due to dewatering (Anderson 2001; James et al. 2000; Meyer 2002). Gold Creek routinely stays dewatered for a month or two, typically lasting into late September (Wissmar and Craig 1997). The dewatering typically begins in reaches above Gold Creek Pond and can be intermittent for over 1.5 miles. Complete dewatering of portions of the Gold Creek channel upstream from the maximum lake elevation has been noted in most recent years. At times, when the channel above the lake is dewatered, that portion of the channel traversing the reservoir bottom may also be impassable due to low Gold Creek flows, shallow water conditions, and the poor stream habitat conditions created by periodic inundation of the stream channel by the reservoir.

Migrating fish commonly can swim through the channel across the exposed lakebed, but cannot swim up the channel above Gold Pond (Brent Renfrow, WDFW, pers. comm.). Adults that haven't migrated into the upper watershed prior to dewatering frequently move into and hold in the flowing reaches of Gold Creek, between Gold Creek Pond and the reservoir. There is evidence that some of the adult fish holding in this lower area move into the upper watershed upon the streams rewatering in the fall, although a few adults are known to spawn in the lower reaches. Redd counts from 1984 to 2001 have ranged from 2 to 51 with an average of 18 (s.d. = 13.3). A rough population estimate for this stock is between 100-200 adult fish and the stock is currently considered at a critically low level. Figures B-6-3 and B-6-4 show Gold Creek flows and water temperatures at two locations from early-to-mid June to late November. Maximum water temperatures

Figure B-6-3. Gold Creek discharges (cfs)

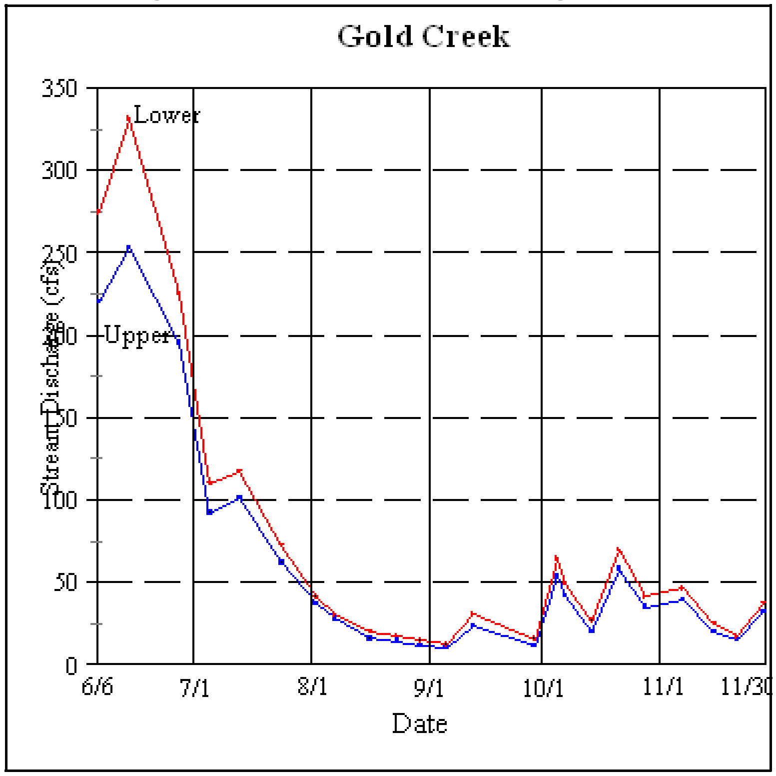
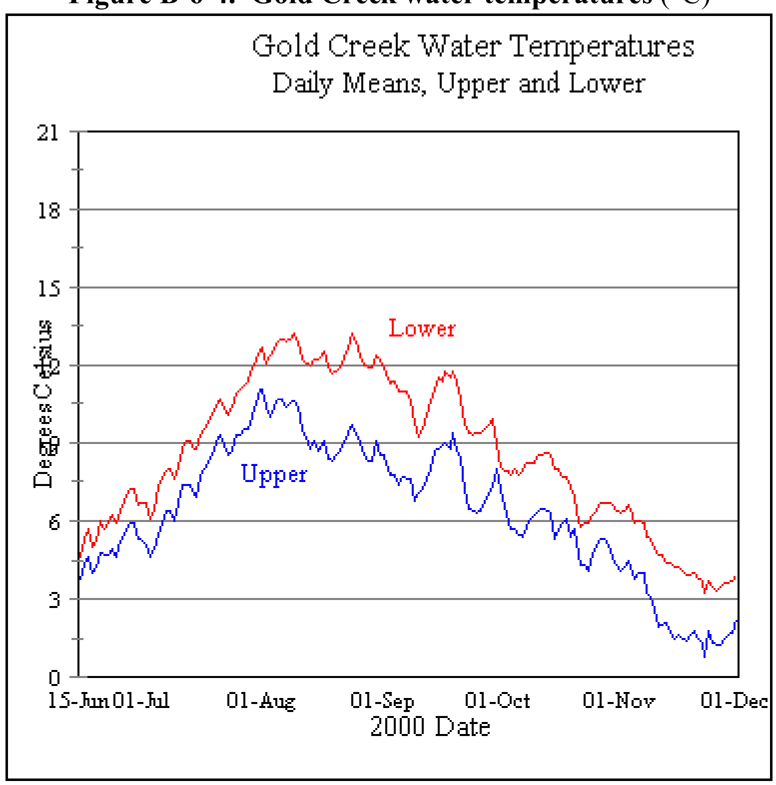


Figure B-6-4. Gold Creek water temperatures (°C)



are less than 15 °C during the warmest part of the summer. Low flow was about 10-12 cfs around the beginning of September 2000.

Gold Creek only met the Forest Plan standard for LWD in one of the six reaches sampled. Historically LWD in Gold Creek included large old growth trees, which would serve as stable key pieces in debris jams. In-channel wood likely was a critical channel roughness element, dissipating stream energy and maintaining the stability of the alluvial channel. All of the large, old growth timber in the lower watershed was logged by 1990; there is now little or no residual key-piece size LWD in-channel and no opportunity for recruitment of new LWD key pieces. Although there is a substantial amount of small and medium sized woody debris in Gold Creek (and more is recruited from the banks with each flood), most all of it is readily mobilized by flood flows. Pieces are not large enough to provide bank protection, stable debris jams and stable LWD-related channel features. Bank erosion is occurring throughout lower Gold Creek and the resulting bedload has caused the channel to become broad and braided. During late summer low flow, the stream flows subsurface within these gravels. Potentially, the reintroduction of stable LWD features would restore bank stability and aid in the return of deep pools and prolong the period when upstream fish passage is possible.

Gold Creek and Meadow Creek are on the Clean Water Act 303(d) impaired water quality list for water temperature.

6.1.3 Cold Creek — The culvert at the old Milwaukee Railroad grade crossing of Cold Creek (about 100 yards upstream from the mouth) is perched and is a total barrier to fish passage. Habitat conditions in Cold Creek upstream from the fish barrier are rated as good (Brent Renfrow, WDFW, 2002, pers. comm..; Tina Mayo, USFS, 2002, pers. comm.) with good LWD presence, riparian shade, and cold water, but none of the reaches sampled in Cold Creek upstream from the culvert met the Forest Plan standards for LWD presence or pool frequency (USFS 1997). Reclamation is in the process of removing or replacing this barrier, which would open up about two additional miles of spawning and rearing habitat for anadromous salmonids. As shown in Figures B-6-5 and B-6-6, Cold Creek has essentially no flow in late August-early September, with maximum water temperature of about 17 °C in late July-early August.

Figure B-6-5. Cold Creek discharges (cfs)

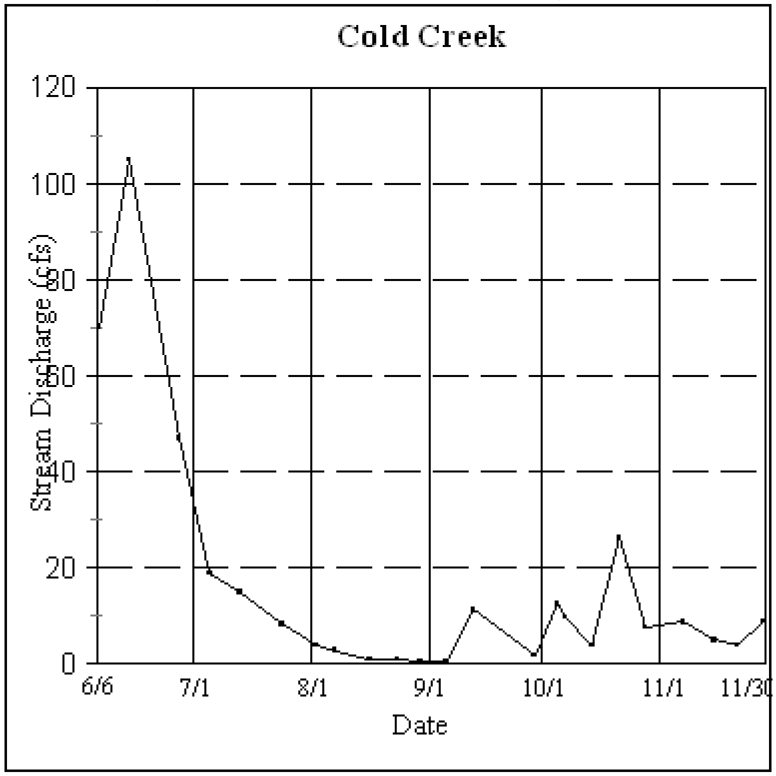
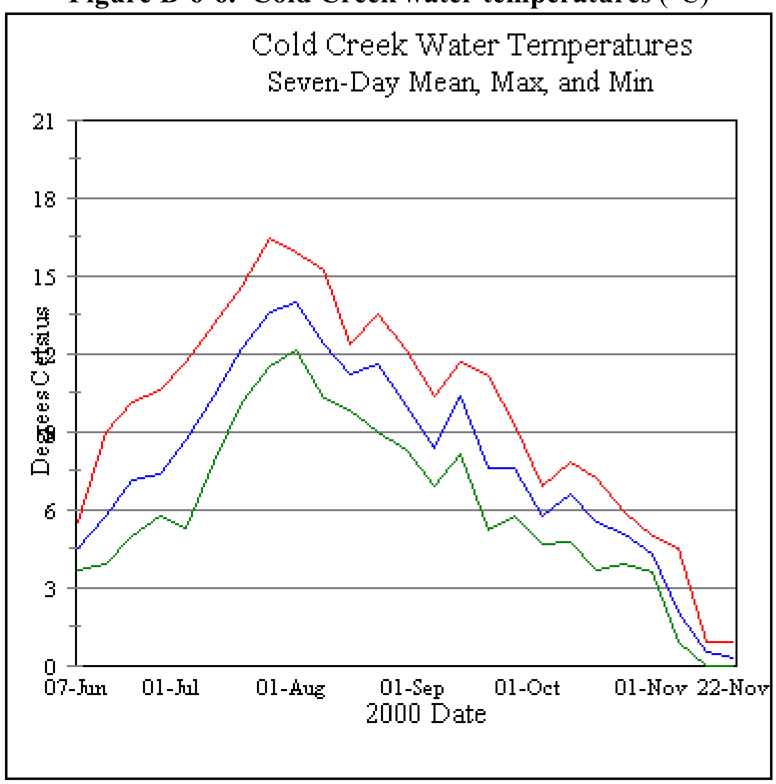


Figure B-6-6. Cold Creek water temperatures (°C)



6.1.4 Coal Creek — Coal Creek has at least two culvert fish passage barriers (one round corrugated metal pipe and one twin concrete box culvert) at crossings under Interstate Highway I-90 upstream from the Hyak interchange (Brent Renfrow, WDFW, 2002, pers. comm.). Natural floodplain function in Coal Creek is highly altered by I-90. The channel has been relocated, confined and straightened as it runs adjacent to the highway (Brent Renfrow, WDFW, 2002, pers. comm.). Much of the drainage is developed (highways, ski areas, and residential development) or clearcut, altering the water storage and runoff characteristics. Habitat conditions in Coal Creek are fair/poor, since much of the stream has been straightened or channelized (or both) along I-90. The daily range of water temperatures observed on Coal Creek during the summer was broad, which is undoubtably the result of extensive stream-side development and degraded riparian conditions. The daily average stream temperature for Coal Creek was the highest of four streams studied by Thomas (2000), although the 7-day average temperatures typically remained below 15 °C throughout most of the study, except for about a one-week period around the end of July-beginning of August. Based on the relatively poor habitat conditions and passage barriers, Coal Creek would not provide suitable spawning and rearing habitat for anadromous salmonids. Figures B-6-7 and B-6-8 show streamflows and water temperatures for Coal Creek from early June to late November. Streamflows are nearly zero in August and early September, while the 7-day average water temperature was greater than 15 °C around the end of July and the maximum water temperature was up to 21 °C during this time period, which would seriously stress bull trout.

Figure B-6-7. Coal Creek discharges (cfs)

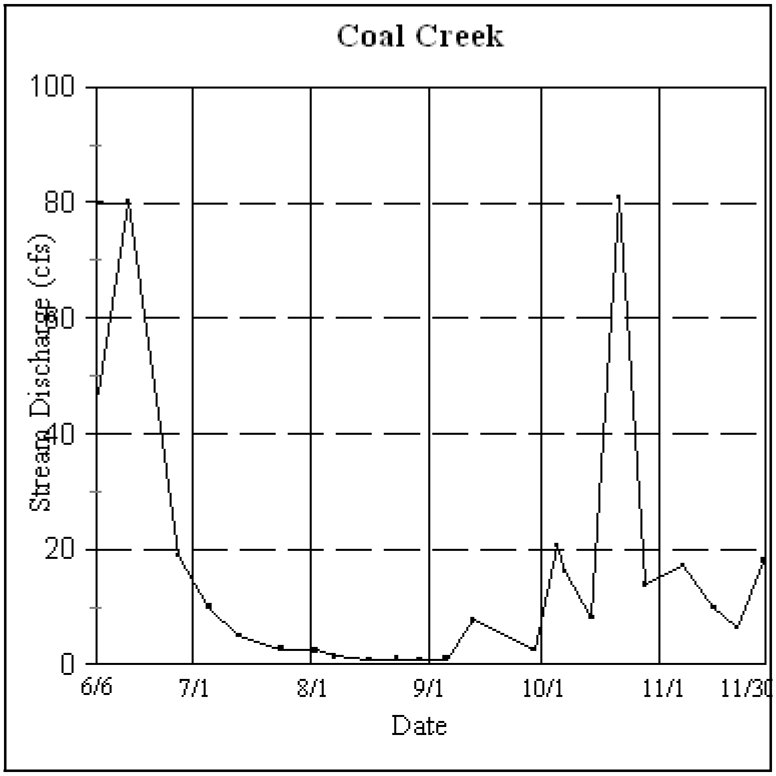
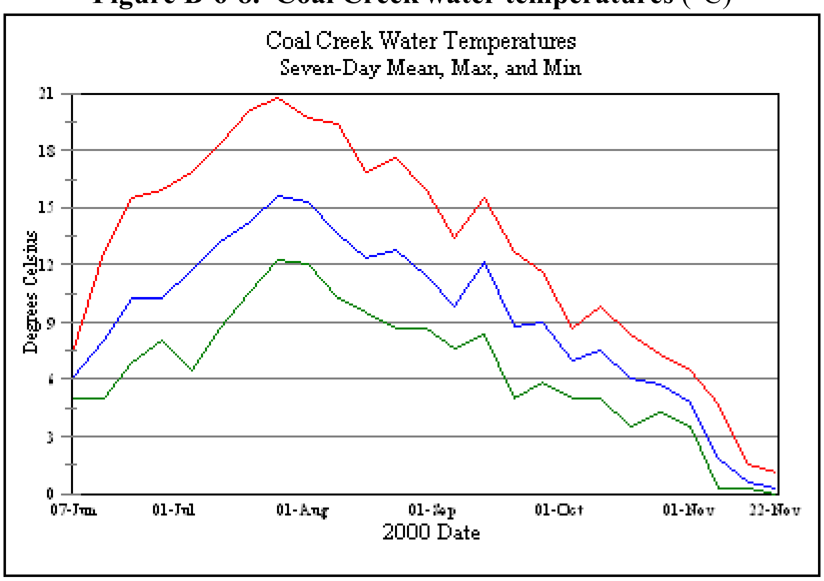


Figure B-6-8. Coal Creek water temperatures (°C)



6.1.5 Mill Creek — Mill Creek is about 2 miles long. A large culvert about RM 0.2 blocks fish passage. As a result, Mill Creek would provide little spawning and rearing habitat for anadromous salmonids even if fish passage was provided at Keechelus Dam.

6.1.6 Keechelus Lake limnology — Self-sustaining runs of kokanee salmon are present in Keechelus Lake, so clearly some food is available re-establish runs of sockeye salmon. Food may be a temporary limiting factor in juvenile growth and survival until anadromous salmonids runs return sufficient marine-derived nutrients to enhance reservoir productivity. Large fluctuations in the water level in the reservoirs may flush out zooplankton or limit primary productivity. Mongillo and Faulconer (1982) noted the reservoir was oligotrophic and suggested that artificial fertilization as a technique to temporarily increase productivity. Recent research conducted by Steve Hiebert (USBR, Denver, CO, 2002, pers. comm.) also preliminarily classifies Keechelus Lake as oligotrophic.

6.2 KACHESS LAKE SUPPORTING DATA

6.2.1 Kachess River — The Kachess River is 5.5 miles long with a natural fish passage barrier 0.9 mile upstream from Kachess Lake (Steve Croci, FWS, Yakima, September 2002, pers. comm.). WDFW found bull trout actively spawning in late-October/early-November 2000 and 2001 in the upper Kachess River upstream from the confluence with Mineral Creek, but not in Mineral Creek (Anderson and Cummins 1992). The Kachess River supports spring chinook salmon, coho (historic) salmon, and summer steelhead spawning and rearing downstream from Kachess Dam, as well as other resident salmonids and non-salmonids. The Kachess River is dry near its confluence with Kachess Lake in late summer through mid-to-late October, depending on fall precipitation. In 2000 and 2001, bull trout were found spawning in the Kachess River after fall rains restored flow. USFS (1997) has identified five fish-passage-barrier culverts in miscellaneous tributaries to the Kachess River and one on Gale Creek (tributary to Kachess Lake). These barriers may impact resident salmonids, but no anadromous salmonids presently occur upstream from Kachess Dam, and bull trout are not known to utilize the streams on which the barriers are located. The *Yakima Watershed Analysis* (USFS 1999) has the specific locations of these barriers.

6.2.2 Box Canyon Creek — Box Canyon Creek is 7.7 miles long (USFS 1995b), with a barrier falls at RM 1.6 (Haring 2001); USFS (1995b) reported that a waterfalls also occurs at about RM 4.5. Stream gradient near this area approaches 40 percent. Historically, the Box Canyon Creek supported sockeye salmon, bull trout, and cutthroat trout (USFS 1995b), with sockeye salmon presumed to have occupied Box Canyon Creek up to the barrier at RM 1.6. Bull trout occur in the mainstem to the barrier at RM 1.6 and may have extended higher into the watershed prior to the washout of a logjam below the falls during the 1990 Thanksgiving flood. The adult bull trout that overwinter in Kachess Lake appear to utilize Box Canyon Creek as their primary spawning ground (Anderson 1995 cited in USFS 1995b). Box Canyon Creek has excellent bed and bank stability due to bedrock and small boulder dominated substrate. LWD abundance and pool frequency were below USFS Forest Plan standards (USFS 1995b). Riparian conditions in Box Canyon Creek have declined between 1942 and 1992 as indicated by aerial surveys. Summertime water temperatures have exceeded Forest Plan standards and ranged as high as 20 °C. Box Canyon Creek has a high risk of road-related sediment problems. The bull trout population is considered at high risk of extirpation (Mongillo 1993, as cited in USFS 1995b), with an estimate of 50 adults in Kachess Lake (Brown 1992, as cited in USFS 1995b).

Other potential spawning streams around Kachess Lake have extensive alluvial aggradations and are highly impacted by lowering of Kachess Lake in late summer and early fall. The combination of reservoir drawdown and aggradation causes these streams to go subsurface at the critical time when adult bull trout are beginning their spawning migration. As the lake is drawn down, the exposed Box Canyon Creek channel on the lake bottom lacks definition as it flows across the permeable lake sediments and may become too shallow for adult bull trout passage (NPPC 2001). Reclamation attempted to correct this in 1996 with construction of a single channel through the inundation zone, but passage problems may still persist under some circumstances. Similar passage problems for bull trout also occur in the Kachess River as it annually dewaters upstream from the reservoir inundation zone.

6.2.3 Mineral Creek — Mineral Creek is 19 miles long, with a natural blockage at 0.25 miles. USFS (1997, cited in Haring 2001) rated 2 miles of spawning habitat, 3 miles of summer rearing habitat, and 3 miles of winter rearing habitat as good in Mineral Creek. The 16 to 17 miles remaining were rated fair or poor.

Bull trout were found in Mineral Creek in 1998 (WDFW 1998, cited in USBR 2000a). WDFW found bull trout actively spawning in late-October/early-November 2000 and 2001 in the upper Kachess River upstream from the confluence with Mineral Creek, but not in Mineral Creek (Anderson and Cummins 1992). In October 2001, one adult bull trout and no redds were found in the lower 0.25 mile of Mineral Creek. Although further investigation is required, a series of cascades on Mineral Creek may block upstream migration of bull trout beyond the lower 0.25 mile, and spawning gravel in the lower end of the creek is scarce.

6.2.4 Gale Creek — Gale Creek is 4 miles long. The 1991 USFS survey delineated four reaches in Gale Creek; there is a waterfall in Reach 3 above RM 1.5. The stream was subsurface for the first 165 feet as a result of lake drawdown during an October 1991 USFS stream survey. The Gale/Thetis Forest Planning Unit has a high total road or open road density, as well as road-related sediment problems (USFS 1997, cited in Haring 2001). Teaches 1, 2, 3, and 4 were 0.75, 0.75, 1.50, and 0.50 miles in length, respectively. Stream gradients in reaches 1, 2, 3, and 4 were 4, 6, 11, and 2 percent, respectively. Substrate composition was cobble/small boulder in reaches 1, 2, and 3 and gravel/cobble in Reach 4. Gale Creek is on the Clean Water Act "303(d)" impaired water quality list for water temperature. During the period 2 July to 10 September 1991, water temperatures ranged from 8 to 20 °C, which exceeded the 7-day average of 14.4 °C recommended by the Forest Plan. However, during the 2-8 October 1991 USFS survey, the stream met the Forest Plan standards for water temperature of 16 °C. The stream does not meet the Forest Plan standards for large woody debris or primary pools. The stream is embedded due to landslides, clearcuts, and recreation (USFS 1991). Riparian conditions vary among reaches, with reach 1 having the lowest percent canopy closure, ranging from 0 to 19 percent. No bull trout were documented in Gale Creek. With impaired water quality conditions especially as related to water temperature, habitat conditions may not be suitable for bull trout.

6.2.5 Thetis Creek — Thetis Creek is 2.7 miles long. In later summer, the creek commonly goes subsurface in he lakebed and upstream.

6.2.6 Lodge Creek — Lodge Creek is a small stream that provides a mix of habitat conditions in about 1.25 miles of accessible habitat. Habitat components include woody debris and wetlands. Brook trout are the most common species of fish observed.

6.2.7 Kachess Lake limnology — Self-sustaining runs of kokanee salmon are present in Kachess Lake, so clearly some food is available in the reservoir for re-establishing runs of sockeye salmon. Food may be a temporary limiting factor in juvenile growth and survival until anadromous runs return sufficient marine-derived nutrients to enhance reservoir productivity. Large fluctuations in the water level in the lake may flush out zooplankton or limit primary productivity. Mongillo and Faulconer (1982) noted the reservoir was oligotrophic and suggested artificial fertilization as a technique to temporarily increase productivity. Hiebert (USBR, Denver, CO, 2002, pers. comm.) classified Kachess Lake as oligotrophic.

6.3 CLE ELUM LAKE SUPPORTING DATA

6.3.1 Cle Elum River — The Cle Elum River is about 21 miles long with a potential barrier to fish migration between Camp and Fortune creeks at about RM 9. Slatick and Park (2000) indicated that "Cle Elum falls" (considered by local fisheries biologists as a series of cascades) would be a barrier to fish movement. But, Renfrow and Thomas (2002, pers. comm.) suggest that larger, stronger adult salmonids could negotiate the falls at least seasonally, which would make the Cle Elum River accessible up to Hyak Lake. Spawning habitat in the reach just above reservoir full pool was judged to consist of intermediate quality substrate, while the next 9 miles (15 km) upstream to the area near Fortune Creek had a combination of intermediate-to-large cobble spawning substrates; however, the river narrows after its confluence with the Cooper and Waptus rivers, so potential spawning habitat is reduced (Slatick and Park 2000).

6.3.2 French Cabin Creek — French Cabin Creek is about 3.7 miles long.

6.3.3 Thorp Creek — Thorp Creek is reported by the Forest Service to be 5.3 miles long. In a 1992 stream survey, USFS segmented the stream into three reaches. Its principal findings were that anadromous salmonids did not use this stream; average gradient was 10%, 12%, and >30% in reaches 1, 2, and 3, respectively; and there were 23 falls, 5 falls, and 7 falls in reaches 1, 2, and 3, respectively. The substrate in Reach 1 was bedrock and cobble; riparian conditions were fair due in part to impacts from previous timber harvest; and large woody debris and pools did not meet Forest Plan standards. Therefore, this creek is unlikely to provide any benefit to anadromous salmonids if fish passage is provided at Cle Elum Dam.

6.3.4 Cooper River — The Cooper River is 6.8 miles long with an impassable falls at RM 0.6. Slatick and Park (2000) reported that spawning conditions in the area of the Cooper River potentially accessible to anadromous salmonids had less spawnable gravel than the river upstream, and would thus not provide substantial benefit to anadromous salmonids if passage were provided at Cle Elum Dam.

6.3.5 Waptus River — The Waptus River is 13.2 miles long, including reaches upstream from Waptus Lake. There is an impassable falls at RM 7.2. Reach 1 (from the mouth to RM 7.2) has a 3.6 percent gradient, with a substrate of bedrock and cobble, while Reach 2 has a 3.8 percent gradient, with a substrate of cobble and gravel. Slatick and Park (2000) indicated that the Waptus River from its confluence with the Cle Elum River to Waptus Falls had poor spawning potential for anadromous salmonids, since the river bed had large cobble and rocks with few pockets of spawnable gravel. Since the falls block upstream fish migration, the potentially better spawning conditions they reported as occurring upstream would not be usable. USFS (1990) reported that the Waptus River is in generally healthy condition, with only large woody debris needing improvement for enhancing bull trout habitat. Reach 1 contained bull trout, rainbow trout, cutthroat trout, and brook trout, and sculpin. Reach 1 had an estimated 8,543 square yards of spawning habitat (USFS

1990). The river has been moderately impacted by recreational use. This river would not provide substantial benefit to anadromous salmonids if passage were provided at Cle Elum Dam due to the poor spawning habitat available in the accessible reach.

6.3.6 Paris Creek — Paris Creek is 1.4 miles long, with an impassable barrier about 0.25 miles upstream from the mouth, and gradient is steep (Jeff Thomas, FWS, October 2002, pers. comm.). It would therefore provide little or no benefit to anadromous salmonids.

6.3.7 Big Boulder Creek — Big Boulder Creek is 2.5 miles long, with an impassable barrier about 0.5 miles upstream from the mouth; in addition, the gradient is steep (Thomas 2002).

6.3.8 Camp Creek — Camp Creek is 0.8 mile long, with an impassable barrier about 0.25 mile upstream from the mouth (Thomas 2002). There a 36 percent gradient at the mouth; at some flows, it is a barrier to fish migration. There is also a high-gradient area at RM 0.6, which also delineates the upstream boundary of Reach 1. Overall gradient in the upper part of Reach 1 ranges from 11 to 20 percent. The substrate is cobble/gravel/small boulders. None of these three creeks (Paris, Big Boulder, and Camp) would benefit anadromous salmonids if passage were provided at Cle Elum Dam.

6.3.9 Fortune Creek — Fortune Creek is 4.5 miles long. Two reaches were surveyed by the Forest Service; Reach 1 was 2.4 miles long and Reach 2 was 0.48 mile long. Reach 2 has numerous falls and a relatively steep gradient of 14 percent. In addition, there is a fish passage barrier downstream from the mouth of Fortune Creek in the mainstem Cle Elum River. The presence of a potential fish passage barrier at Cle Elum RM 9 might prevent use of Fortune Creek by anadromous salmonids and would not benefit anadromous salmonids that would otherwise have access to the reservoir and upstream tributaries if fish passage was provided at Cle Elum Dam.

6.3.10 Cle Elum Lake limnology — Self-sustaining runs of kokanee salmon are present in Cle Elum Lake, so clearly some food is available for re-establishing runs of sockeye salmon. Food may be a temporary limiting factor in juvenile growth and survival until anadromous runs return sufficient marine-derived nutrients to enhance reservoir productivity. Large fluctuations in the water level in the reservoirs may flush out zooplankton or limit primary productivity. Mongillo and Faulconer (1982) noted the reservoir was oligotrophic and suggested artificial fertilization as a technique to temporarily increase productivity. The carcasses of spawned-out salmon in streams entering Cle Elum Lake historically provided a substantial and reliable source of marine-derived nutrients, which was greatly reduced once the crib dam obstructed the salmon runs (Flagg et al. 2000). Bioassays conducted by Mongillo and Faulconer (1982) found growth of algal mass to be phosphorous limited. Statistical analysis of sediment cores in the lake indicate that prior to 1906 (the year of initial crib dam construction that blocked fish passage), there was an average of 19 percent more phosphorous deposited in lake sediments each year than there has been since 1906. These results suggest that salmon runs were probably eliminated by construction of the crib dam in 1906, rather than by the 1933 storage dam, and that salmon carcasses once contributed appreciably to the phosphorous load of Cle Elum Lake. Recent research conducted by Steve Hiebert (USBR, Denver, CO, 2002, pers. comm.) classified Cle Elum Lake as oligotrophic.

6.4 BUMPING LAKE SUPPORTING DATA

6.4.1 Bumping River — Bumping River is 8.2 miles long, with a natural barrier to fish passage about 1 mile upstream. Watson (cited in Haring 2001) noted that the Bumping River/Bumping Lake watershed might provide the best opportunity to restore sockeye salmon in the Yakima Basin.

6.4.2 Deep Creek — Deep Creek is 8.5 miles long, with a natural barrier 5 miles upstream from the confluence with Bumping Reservoir and approximately 300 m (1,000 feet) upstream from Forest Road 2008 crossing. The lower 0.5 mile of Deep Creek goes subsurface during low water years. Bull trout currently occupy Deep Creek (WDFW 2002), which is essential spawning and rearing habitat for the Deep Creek local population.

6.4.3 Bumping Lake limnology — Bumping Lake is a relatively small irrigation storage reservoir. Annual water level fluctuation and the rapid flushing rate likely reduce primary and secondary production, resulting in an oligotrophic reservoir. Hiebert (USBR, Denver, CO, 2002, pers. comm.) classified Bumping Lake as oligotrophic.

6.5 RIMROCK LAKE SUPPORTING DATA

6.5.1 South Fork Tieton River — The South Fork Tieton River is 17.5 miles long (USFS 2000) from the confluence with Rimrock Reservoir. It has a falls at RM 13.5 (and a natural barrier at RM 16.8), so potential habitat accessible to anadromous salmonids is about 13.5 miles if passage were provided at Tieton Dam. Bull trout currently occupy the South Fork Tieton River (WDFW 2002), which is essential spawning and rearing habitat for this population.

Stream surveys were conducted by the USFS in 1991 and 2000, in which the river was divided into reaches; however, they designated the reaches differently for each survey. In the 2000 survey, reaches 1, 2, and 3 were upstream from those with the same designation in the earlier survey. Gradients for these three reaches ranged from 1 to about 3 percent. Water temperature during the surveys met the Forest Plan standards, while pools and large woody debris did not meet standards. During the 2000 survey, 85 bull trout redds were identified, indicating relatively good conditions for spawning.

6.5.2 Short and Dirty Creek — Short and Dirty Creek is 3.0 miles long with a natural barrier approximately 0.1 miles upstream from the confluence with the South Fork Tieton River. Bull trout currently occupy Short and Dirty Creek (WDFW 1998), which is essential rearing habitat for the South Fork Tieton River local population. Anderson (1997) cited in Craig (1997) noted that juvenile bull trout and cutthroat trout have been recorded in the creek, but no adult spawners.

6.5.3 Corral Creek — Corral Creek is 2.5 miles long, with a falls at RM 2.2. There are also culverts on Forest Roads 1000 and 1040. Water temperature ranged from 45 to 61 °F during the 7 July-25 September 1998 survey. Stream gradient is 2-5 percent near the mouth and increases progressively upstream to about 17 percent. Timber harvest, livestock grazing, and mining have occurred in this drainage and have impacted the riparian zone. Hunting, motorized ORV (off-road vehicle) travel, and dispersed camping are recent activities in the drainage.

6.5.4 Bear Creek (South Fork Tieton) — Bear Creek (South Fork Tieton River) is 1.9 miles long with a natural barrier approximately 1.1 miles upstream from the confluence with the South Fork Tieton River. Bull trout currently occupy Bear Creek (South Fork Tieton) (WDFW 2002), which is essential spawning and rearing habitat for the South Fork Tieton River local population. Craig (1997) noted that bull trout spawning is restricted to 0.56 miles of habitat downstream from a natural falls.

6.5.5 Bear Creek (Rimrock) — Bear Creek (Rimrock) has a culvert at 3.7 miles from the mouth. The mean stream gradient is 3 percent. The stream has high sedimentation, and does not meet Forest Plan standards for pool frequency.

6.5.6 North Fork Tieton River — The North Fork Tieton River is about 12 miles long from its confluence with Clear Lake Reservoir, with a natural barrier 9.8 miles upstream from the confluence with Clear Lake Reservoir (Craig 1997). Bull trout currently occupy the North Fork Tieton River (Craig 1997), which is essential spawning and rearing habitat for the North Fork Tieton River local population. This local population is not monitored annually. The ladder on Clear Lake Dam is ineffective in providing fish passage.

6.5.7 Clear Creek — Clear Creek has a large spring located about 1.8 mile upstream from the lake that provides the majority of the discharge during baseflow periods (Craig 1997). The creek upstream from the springs is seasonally dewatered, which restricts spawning habitat to the area downstream from the springs.

6.5.8 Indian Creek — Indian Creek is 6 miles long, with a natural barrier 4.9 miles upstream from the confluence with Rimrock Reservoir (Craig 1997). Bull trout currently occupy Indian Creek (Craig 1997; WDFW 2002) up to the falls, which is essential spawning and rearing habitat for the Indian Creek local population. Spawning substrate is extremely limited upstream from the falls (Craig 1997). The unconstrained alluvial valley of Indian Creek subjected the creek to massive channel changes (Craig 1997).

6.5.9 Clear Lake — Bull trout currently occupy Clear Lake (WDFW 1998) but probably in extremely low abundance. Clear Lake has a capacity of 5,300 acre-feet and provides essential foraging and overwintering habitat for the North Fork Tieton River local bull trout population. The existing fish ladder at Clear Lake Dam is ineffective in providing fish passage. If fish passage at Clear Lake Dam is improved, it will provide a migratory corridor to other local populations within the Yakima River.

6.5.10 Rimrock Lake limnology — Rimrock Lake is more productive than the other four reservoirs in the Yakima Basin, based on an analysis of chlorophyll *a* and nutrients (Davine Lieberman, USBR, Denver, CO, 2003, pers. comm.), and is classified as mesotrophic.

Table B-6-1 shows the tributary habitat conditions upstream from the five reservoirs as summarized in the Habitat Limiting Factors (Haring 2001). Some of the information in this summary as well as the information compiled in this appendix and Appendix C, were used to assign a "good" composite rating to the assemblage of tributaries upstream from the reservoirs.

Table B-6-1. Summary comparison of tributary habitat conditions upstream from five Yakima basin storage dams and reservoirs										
Tributaries upstream from	**Fish access**	**Floodplain connectivity**	**Channel Conditions**		**Substrate**	**Riparian Conditions**	**Water Quality**		**Hydrology**	
			LWD	**Pools**			**Temp/DO**	**Toxics**	**Peak Flow**	**Low Flow**
Keechelus Dam	P	P-G	P	P	P-G	P-G	F-G	DG	G	P-G
Kachess Dam	P	F	P	P	F	F	F	G	G	G
Cle Elum Dam	P	G	G	F	G	G	DG	G	G	G
Bumping Dam	P	G	G	F	G	G	G	G	G	G
Tieton Dam	P	P-G	G	G	F	F-G	P	G	G	G

Habitat condition rating information extracted and modified from Table 39 (p 313-314) of *Habitat Limiting Factors, Yakima River Watershed, Water Resource Inventory Areas 37-30, Final Report* (Haring 2001) report for the Yakima River Watershed

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